PRINTED ON THIN PAPER FOR FOREIGN CIRCULATION.

APR 14 1924

ENGINEERING:

An Illustrated Weekly Journal.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C. 2.

VOL. CXVII.—No. 3039.] *LONDON: FRIDAY, MARCH 28, 1924.* [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 3½d.

Aveling & Porter, Ltd.,
ROCHESTER.
1869
Steam Road Rollers & Tractors.

A. G. Mumford, Ltd.,
CULVER STREET WORKS, COLCHESTER.
ON ADMIRALTY AND WAR OFFICE LISTS.
ENGINES for Torpedo Boats, Yachts, Launches. BOILER FEED PUMPS.
See Advertisement page 37.
PATENT WATER-TUBE BOILERS. AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

E. J. Davis, M.I.Mech.E., Gas Engines Inspected, Tested and Reported upon. Over 25 years' experience. Tel.: Maryland 1736 & 1737. Wire: "Rapidising, London." —Great Eastern Road, Stratford, E. 15. 1794

David Brown & Sons (Hudd.) Ltd.
Lockwood Huddersfield.
HIGH CLASS
Machine Cut Gearing
FOR EVERY PURPOSE. 1440

THE GLASGOW ROLLING STOCK AND PLANT WORKS.
Hurst, Nelson & Co., Ltd.,
Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS, and EVERY OTHER DESCRIPTION OF RAILWAY and TRAMWAY ROLLING STOCK. Makers of WHEELS and AXLES. RAILWAY PLANT, FORGINGS, SMITH WORK, IRON & BRASS CASTINGS, PRESSED STEEL WORK OF ALL KINDS. Od3382
Reg. Office and Chief Works: Motherwell. London Office: 33, Great St. Helens, Bishopsgate, E.C. 3.

Tank Locomotives.
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO., LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 1865

Spencer-Hopwood & Kirke
PATENT 1994
BOILERS. *See page* 71, *March* 21.
Sole Makers: SPENCER BONECOURT, LTD., Parliament Mansions, Victoria St., London, S.W.

The Glasgow Railway Engineering Company,
GOVAN, GLASGOW. LTD.,
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 1943

Punching Bears.
FELLOWS BROS., LTD., 9158
CRADLEY HEATH, STAFFS.

Steam Hammers (with or without guides). Hand-worked or self-acting TOOLS for SHIPBUILDERS & BOILERMAKERS. 1914
DAVIS & PRIMROSE, LIMITED, LEITH, EDINBURGH.

Bever, Dorling & Co., Ltd.,
BRADFORD.
HIGH-CLASS ENGINES FOR ALL PURPOSES, also WINDING, HAULING, AIR COMPRESSING and PUMPING ENGINES. 1896

GOLD MEDAL-INVENTIONS EXHIBITION-AWARDED
Duckham's Patent Suspended
WEIGHING MACHINES—EAST FERRY ROAD ENGINEERING WORKS COMPANY, LTD. LONDON, E.—Hydraulic Cranes, Grain Elevators, &c. See illus. Advt. last week, page 15. 1715

CRANES. All Types.
GEORGE RUSSELL & CO., LTD., Motherwell. 1967

Telegrams:—"Cylinders," Birmingham.
Weldless-Steel Tubes
for Water-tube Boilers, Superheaters, Shifting, Hydraulic Work, Boring Rods, &c.
TUBES LIMITED, BIRMINGHAM. O8179

YARROW & CO. (1922), LTD., GLASGOW.
PASSENGER AND CARGO STEAMERS.
SHALLOW DRAFT VESSELS. 1553

Campbells & Hunter, Ltd.
SPECIALISTS IN
Drillers & Boring Machinery
for Engine Works and Boiler Shops.
DOLPHIN FOUNDRY, LEEDS. 4547

VOSPER & CO., LTD.,
PORTSMOUTH.
SHIP & LAUNCH BUILDERS, Od 3551
ENGINEERS & BOILER MAKERS.

For Your Repairs or any
SPECIAL MACHINERY, try THOMAS HUNT & SONS, Albion Ironworks, Bridge Road West, Battersea, S.W. 11. Est. 1854. 2007

The Mitchell Conveyor and
TRANSPORTER CO., LTD., CONTRACTING ENGINEERS.
DESIGNERS and BUILDERS of all Classes of HANDLING MACHINERY.
Atlantic House, 45-50, Holborn Viaduct, London, E.C. 1.
Telegrams: "Micontraco, Cent, London." Telephone: Holborn 2822. 1713

Dredging Plant—
For ALLUVIAL GOLD, PLATINUM & TIN, HARBOUR, RIVER & CANAL.—Gravel Dredgers, SCREENS.—DREDGE BUCKETS & Parts, all sizes.
ARTHUR R. BROWN, 84, New Broad Street, London, E.C.2. Telephone: London Wall 3418. 1814

RAILWAY AND TRAMWAY ROLLING STOCK.
Hurst, Nelson & Co., Ltd.,
THE GLASGOW ROLLING STOCK AND PLANT WORKS, MOTHERWELL. Od 3383

P. & W. MacLellan, Ltd.,
CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF RAILWAY CARRIAGES AND WAGONS OF EVERY DESCRIPTION.
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
Chief Offices: 129, Trongate, Glasgow. Od 3547
Registered Offices: Clutha House, 10, Princes St., Westminster, S.W. 1.

Patent
See's Hydro-Pneumatic Ash Ejector
Great saving of labour. No noise. No dust. No dirt. Ashes discharged 20 ft. clear of vessel.—Apply, F. J. TREWENT & PROCTOR, LTD., Naval Architects and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4835

Penningtons, University
TUTORS, 264, Oxford Road, Manchester. Estab. 1876. Enrol now for I.C.E. and I.M.E. Postal Courses. 100 per cent. passes last Exams. Reinforced Concrete—a new comprehensive course under expert engineer, £3 3s. Write for particulars. 1711

Iron and Steel
Tubes and Fittings.
Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 817
The Scottish Tube Co., Ltd.,
HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement page 79.

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, STEAM and GAS KETTLES, Merrill's Patent TWIN STRAINERS for Pump Suctions. } Row's PATENTS.
SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 5723

IRON & STEEL
Tubes AND Fittings
AND
Steel Plates.
STEWARTS AND LLOYDS, Ltd.
GLASGOW BIRMINGHAM - LONDON.
See Advertisement, page 27. 1872

Electric Generating Plant for SALE.
Direct Current.

Two	26 Kw.	105 Volts		"Howden-B.B.H.
Two	52	"	"	"Brotherhood - Laurence Scott."
Two	100	"	440/500	" Gerrett Semi-Portable.
One	120	"	110	" "Belliss-Siemens."
One	150	"	220	" "Howden-Lane. Dynamo."
Two	200	"	"	" "W. H. ALLEN."
Two	200	"	"	" "Belliss-Siemens."
One	240	"	440/500	" "Belliss-Phœnix Dynamo."
One	375	"	250	" "Allen-Westinghouse."
One	460	"	240	" "Howden-Siemens."
One	500	"	230	" "Howden-B.T.H."
One	500	"	230	" "Belliss-B.T.H."
One	500	"	500	" Metropolitan Vickers Turbo.
One	660	"	500	" "Belliss-Mather & Platt."
One	750	"	220	" "Parsons - Crompton" Geared Turbo.
One	1250	"	250	" "Belliss" Turbo.

Alternating Current, 3-Phase, 50 Periods.

One	400 Kw.	500/550 Volts.		"Howden-G.E.C."
One	750	"	"	" "Metropolitan-Vickers."
One	850	"	"	" "Fraser & Chalmers."
Two	1000	"	"	" "Metropolitan-Vickers."
One	1000	"	3300	" "B.T.H."
Two	1000	"	"	" "Metropolitan-Vickers."
One	2000	"	500/550	"
One	3000	"	6600	" "B.H.T." "

All above are modern, and condensing plant is available in nearly all cases.
We can also offer several Suction Gas and Diesel Sets, Babcock Boilers up to 30,000 lbs. per hour, and a very large number of motors, generators, Motor-generators, rotary converters, etc.
Enquiries Invited.
THE PHŒNIX ELECTRICAL COMPANY, LTD., 17, OSWALD STREET, GLASGOW. 822

ON ADMIRALTY LIST.
John Kirkaldy, Ltd.,
London Office: 101, LEADENHALL ST., E.C.3.
Works: BURNT MILL, near HARLOW, ESSEX.
Makers of
Evaporating and Distilling Plants.
Refrigerating and Ice-making Machinery.
Feed Water Heaters.
Evaporators.
Fresh Water Distillers.
Main Feed Pumps.
Combined Circulating and Air Pumps.
Auxiliary Surface Condensers, &c., &c. 1586

For Sale, Motor-Driven Air COMPRESSOR, by Belliss & Morcom. 1000 cubic ft. per min. 100 lbs. pressure, with 500 volt D.C. motor.—THE PHŒNIX ELECTRICAL CO., LTD., 17, Oswald Street, Glasgow. D 231

Regent Guillotine Shears and Power Presses
FOR SHEET AND PLATE WORKING.
THE REGENT SHEET METAL MACHINE TOOL CO., LTD., REGENT WORKS, WAKEFIELD. 2015

HEAT INSULATION.
CELITE PRODUCTS CORPORATION, Windsor House, Westminster, S.W.1. 1675
See our Illustrated Advertisement, March 14.

YARROW & CO. (1922), LTD., GLASGOW.
LAND AND MARINE
YARROW BOILERS. 1553

John Bellamy Limited,
MILLWALL, LONDON, E.
GENERAL CONSTRUCTIONAL ENGINEERS. 1316
Boilers, Tanks & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETTED STEAM and VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

Head, Wrightson & Co.,
LIMITED.
See Advertisement page 61, March 21. 2403

53 HP. Crossley Suction Gas ENGINE, latest design; magneto ignition, variable governing and single flywheel.—HARRY H. GARDAM & CO., LIMITED, Staines. D 243

For Sale, Motor Generator, by Lancashire Dynamo Co. Ltd., 1920, Comprising, 480 volt, D.C. Motor, coupled to 105 volt, 830 ampere compound interpole Generator, complete with switchboard.
THE PHŒNIX ELECTRICAL CO., LTD., 17, Oswald Street, Glasgow. C 475

Cement.—Maxted & Knott, LTD., Consulting Cement Engineers, ADVISE GENERALLY on proposed Cement Schemes FOR ENGLAND AND ABROAD. ADVICE ONLY. Highest References. Established 1890.
Address, BURNETT AVENUE, HULL.
Cablegrams: "Energy, Hull." 1893

Railway Switches and Crossings
T. SUMMERSON & SONS, LIMITED, DARLINGTON. 2006

Plenty and Son, LIMITED, STATIONARY, STEAM AND MARINE ENGINEERS.
NEWBURY, ENGLAND. 1831

WAYGOOD OTIS LIFTS 1415
54 & 55, PETTER LANE, LONDON, E.C. 4, 62 & 63, LIONEL STREET, BIRMINGHAM, and Principal Provincial Cities and Abroad.

Diesel Engines, 300, 530, 800 and 1,200 B.HP., M.A.N., with or without dynamos; condition as new. About one-third market price; seen London. All spares for above sizes in stock.
HICK DIESEL OIL ENGINES, LTD., 70, Queen Victoria Street, E.C. 4. 3043

Petter Oil Engines.
For Paraffin and Crude Oil
Sizes 1½ B.HP. and upwards.
Petters Limited, Yeovil.
Sizes 25 to 500 B.HP.
Vickers-Petters, Ltd., Ipswich
See advertisement alternate weeks. 2835

Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND.
1676
See half-page Advertisement, page 68, March 14.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
Chief Engineer: C. E. STROMEYER, M.I.C.E.
Founded 1854 by Sir WILLIAM FAIRBAIRN.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 2005
TO ENGINEERS, MACHINISTS, AND OTHERS.

The London Board of Shechetа

OFFER THREE PRIZES for a Machine or other Apparatus for the purpose of casting animals to be slaughtered for food, the essentials to be simplicity, expedition and without suffering to the animals
First Prize £50; Second £35; Third £15.
The Board to have the right to acquire for a sum not exceeding £500 the patent or patents and all rights thereunder of any machine or apparatus submitted.
Any further particulars may be obtained from
The SECRETARY
to the London Shechetа Board,
Vestry Room, Heneage Lane,
Bevis Marks, E.C. 3,
to whom drawings with specifications must be sent under cover not later than the 1st June, 1924, the Board not to be liable for the safe custody or return of same. D 256

Correspondence Courses for

Inst.Civil Engrs., Inst.Mech.E.,London Univ (Matric., inter., B.Sc.), and All ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst C.E., M.R.S.I., F.R.S.A., etc. Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 8/11, TRAFFORD CHAMBERS, 58, SOUTH JOHN STREET, LIVERPOOL. 1993

Engineering Salesmanship

and SALES MANAGEMENT.—Write for brochure describing our special Course of Training for posts of unlimited scope in this lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 383, Oxford Road, Manchester. 1879

TENDERS.

LODGE HILL, near CHATHAM.

Tenders are Invited for

the PURCHASE and REMOVAL of the undermentioned TIMBER-FRAMED HUTS, now at Chattenden Farm, Lodge Hill, and of approximate floor measurements as follows:—

4 No. — 80 feet by 16 feet.
1 No. — 31 „ by 29 „
1 No. — 61 „ by 29 „
1 No. — 61 „ by 16 „

Tenders to be delivered not later than Noon on 4th April, 1924, to SUPERINTENDING CIVIL ENGINEER, H.M. Dockyard, Chatham, from whom full particulars and Forms of Tender may be obtained. D 253

MINISTRY OF TRANSPORT.

SURFACING OF ARTERIAL ROADS.

The Minister is prepared to receive

Tenders for Bituminous

SURFACING in connection with certain sections of Arterial Roads in Essex.
Specifications, Bills of Quantities, Forms and Conditions of Tender may be obtained from the Chief Engineer, Arterial Roads Department, Ministry of Transport, 7, Whitehall Gardens, S.W.1, upon payment of a deposit of £25.
This amount will be returned to the Tenderer if his Tender is a *bona fide* one, and has not been withdrawn prior to the definite acceptance of a Tender by the Minister.
The Drawings and Conditions of Contract may be inspected at the Ministry, and copies of the Specification, Bill of Quantities, etc., will be available on and after the 28th March, 1924.
Tenders on the official form, and accompanied by a fully priced Bill of Quantities, must be submitted in a sealed envelope endorsed "Tender for Essex Arterial Roads, Second Surfacing Programme."
The Minister does not bind himself to accept the lowest or any Tender.
Tenders must reach the undersigned by Ten a.m. on the 10th day of April, 1924.
Dated this 20th day of March, 1924.
(Sd.) H. H. PIGGOTT,
Assistant Secretary.
Ministry of Transport. D 297

BOROUGH OF POOLE.

The Corporation of Poole are prepared to receive

Tenders for the Supply and

CONSTRUCTION of a NEW BRIDGE over the Channel dividing Poole from Hamworthy. The bridge, which will have a total length of 300 feet, will consist of three reinforced concrete spans on each side and one steel opening span of 60 feet clear in the centre of the bridge; this opening span will rest on two piers, each pier being made up of four cylinders varying from 7 feet to 13 feet in diameter with top platform of reinforced concrete.
Plans and draft contract can be seen and the Specification, Schedule of Quantities and Form of Tender obtained at the Offices of the Consulting Engineers, Messrs. LIVESEY, SON & HENDERSON, 14, South Place, London, E.C. 2, on and from Monday the 31st day of March, 1924, between the hours of 10.30 a.m. and Four p.m., upon payment of a deposit of Five guineas, which deposit will be returned upon receipt of a *bona-fide* Tender which is not subsequently withdrawn by the Contractor.
Tenders must be on the official form, each Tender in a sealed envelope marked "Poole Bridge." Tenders must be accompanied by the General Conditions, Specification and Schedule as issued by the Consulting Engineers.
Each Tender must be signed in the handwriting of the Tenderer or his authorised agent.
The Council does not bind itself to accept the lowest or any Tender.
Tenders must reach the undersigned by Nine a.m. on Monday, the 28th of April, 1924.
CHARLES LISBY,
Town Clerk.
Town Clerk's Office,
POOLE, Dorset.
25th March, 1924. D 313

GREAT NORTHERN RAILWAY (IRELAND).

TO MANUFACTURERS OF SWITCHES AND CROSSINGS.

The Directors are prepared to receive

Tenders for the Supply of

SWITCHES and BUILT CROSSINGS, with Chairs for same.
Copies of the Drawing and Specification may be obtained from the undersigned on payment of Two Guineas, which will be refunded on receipt of a *bona fide* Tender, and the return of the Drawings
Tenders, made out on forms supplied by the Company, should be delivered, under sealed cover, endorsed "TENDER FOR SWITCHES, &c.," not later than Ten a.m. on Monday, 14th April, 1924.
The Directors do not bind themselves to accept the lowest or any Tender.
J. B. STEPHENS,
Secretary.
Amiens Street Station,
DUBLIN, 26th March, 1924. D 332

KETTERING URBAN DISTRICT COUNCIL.

SALE OF A DIFFERENTIAL STEAM PUMP.

The above Council

Offer for Sale a Differential

STEAM PUMP, by Hathorn Davey & Company, which has a pumping duty of 1000 gallons per minute against a 40 ft. head; together with a CORNISH BOILER working at 60 lbs. steam pressure. The Pump and Boiler are fixed at the Clover Hill Waterworks, Kettering, and further particulars regarding them may be obtained from the Council's Surveyor, Mr. T. READER SMITH, Market Place, Kettering.
Offers, endorsed "Pump—Clover Hill," must reach me on or before Tuesday, the 8th April next.
The Council do not bind themselves to accept the highest or any Offer.
JOHN BOND,
Clerk to the Council.
Council Offices, Kettering.
25th March, 1924. D 321

CITY OF BIRMINGHAM.

WATER DEPARTMENT.

SALE OF PUMPING MACHINERY.

Tenders are Invited for the

PURCHASE, DISMANTLING and REMOVAL of PUMPING MACHINERY, BOILERS, etc., at Plant's Brook Pumping Station, near Minworth, Warwickshire, comprising:—
One 200 H.P., Compound Differential Pumping Engine, in excellent condition, manufactured by Messrs. Hathorn, Davey & Co., of Leeds.
One 100 H.P. Cornish Engine (old).
Four Roots' Boilers (old), steam pipes, etc.
Full particulars, together with Form of Tender and Permit to view, may be had on application to the undersigned.
J. H. BROADLEY,
Secretary.
Water Department,
Council House,
BIRMINGHAM.
25th March, 1924. D 300

COUNTY BOROUGH OF WOLVERHAMPTON.

WATERWORKS UNDERTAKING.

15 in. and 12in. CAST IRON TRUNK MAINS.

The Wolverhampton Corporation is prepared to receive

Tenders for Providing and

LAYING about 5400 yards of 15 in. and 2950 yards of 12in. CAST IRON WATER MAINS, and Executing other Work in connection therewith, from Contractors who pay to the whole of their employees such remuneration and observe such hours of employment as are recognised by the Employees' Unions and Associations of Employers in the several localities where the work is done.
A copy of the Specification, Quantities, and Form of Tender may be obtained from Mr. H. A. B. WOODWARD, Waterworks Engineer, Town Hall, Wolverhampton, upon payment of the sum of £2 sterling, which amount will be returned to each Contractor who submits a *bona fide* Tender, but not otherwise.
Each Tender must be enclosed in a sealed envelope, addressed to "The Chairman of the Water Committee," and endorsed "Trunk Mains," and delivered at my Office on or before Ten a.m. on Tuesday the 15th day of April, 1924.
The right to decline the lowest or any Tender is reserved to the Corporation.
F. H. WARBRICK HOWELL,
Town Clerk.
Town Hall, Wolverhampton.
5th March, 1924. D 178

AMERSHAM UNION.

TENDERS FOR NEW BOILER HOUSE, ENGINE ROOM AND LAUNDRY BUILDING, ENGINEERING PLANT, HEATING AND HOT WATER SUPPLIES, LAUNDRY EQUIPMENT, ETC.

The Guardians are prepared to invite

Tenders, subject to the

Sanction of the Ministry of Health, for the above WORKS at the Amersham Poor Law Institution.
Firms wishing to Tender for (a) Building Works (confined to Firms carrying on business within the area of Amersham Union), (b) Engineering Works, comprising Chimney Shaft, Boilers, Heating and Hot Water Supplies, (c) Water Softener, (d) Laundry Equipment, to the plans and specifications prepared for the purpose by the Guardians' Architect, Mr. ERNEST E. FETCH, A.R.I.B.A., are requested to submit their names to the Clerk with references to similar recent work carried out by them at other Institutions, on or before the 4th April next.
Firms wishing to Tender are requested, in the first instance, to examine at the Institution, by appointment, the plans and specifications showing the extent of the works, after which a set of plans and specifications will be supplied to the firms selected by the Board or its special Committee to Tender, on receipt of a deposit of £1 10s., which sum will be refunded if a *bona fide* Tender is submitted.
W. J. STANDRING,
Clerk to the Guardians.
Amersham, Bucks.
25th March, 1924. D 314

THE GREAT INDIAN PENINSULA RAILWAY COMPANY, 48, COPTHALL AVENUE, LONDON, E.C.2, invite

Tenders for:—

1. CARRIAGE DOOR HANDLES, HINGES, &c. ... ... Fee 2s. 6d.
2. STEEL FISHBOLTS, CHAIRBOLTS, SPIKES, &c. ... ... „ 10s.
3. STEEL RAILS & FISHPLATES „ £1.
4. PLATE GLASS, &c. ... ... „ 10s.

Tenders are due by Eleven a.m., on 8th April, 1924. Tender Forms obtainable at above address. Fees not returnable. D 333

TAF FECHAN WATER SUPPLY BOARD.

TENDERS FOR FILTERS.

Tenders are Invited from

British Manufacturers of Filters for the SUPPLY, DELIVERY, and ERECTION of PRESSURE or GRAVITY TYPES of FILTERS to deal with 7½ million gallons of water per day of 24 hours.
Particulars can be obtained on application to the Engineers, Messrs. SIR ALEX. BINNIE, SON & DEACON, 30, Buckingham Gate, Westminster, S.W.1, on payment of a cheque for £5 made out to the Taf Fechan Water Supply Board, which sum will be returned on receipt of a *bona-fide* Tender.
Sealed Tenders, accompanied by detail Drawings and Specifications, should be delivered at my Office at or before Noon on Wednesday the 23rd day of April, 1924, endorsed "Tender for Filters."
No Tender will be considered except for a type of Filter which has already been adopted for a scheme of magnitude.
The Board do not bind themselves to accept the lowest or any Tender, or to defray any expenses in connection with Tendering.
J. COLENSO JONES,
Clerk to the Board.
Board's Offices,
MERTHYR TYDFIL,
27th March, 1924. D 335

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED, are prepared to receive

Tenders for the Supply of:—

1. COPPER TUBES, BRASS SHEETS, etc.
2. SOLID DRAWN STEEL BOILER TUBES.
3. METALS.
4. SPARE PARTS of Locomotive Engines.
5. STRUCTURAL STEELWORK (Machine Shop).

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W.1.
Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked;—
"Tender for Copper Tubes, Brass Sheets, etc.," or as the case may be, must be left with the undersigned not later than Twelve Noon on Friday, the 11th April, 1924, in respect of Specifications Nos. 1, 2 and 3, the 25th April, 1924, in respect of Specification No. 4, and 30th May, 1924, in respect of Specification No. 5.
The Directors do not bind themselves to accept the lowest or any Tender.
A charge, which will not be returned, will be made of:—
5s. for each copy of Specifications Nos. 1 & 2.
10s. „ „ „ „ Nos. 3 & 4.
£1 „ „ „ Specification No. 5.
Copies of the drawings may be obtained at the Offices of Messrs. ROBERT WHITE & PARTNERS, Consulting Engineers to the Company, 3, Victoria Street, Westminster, S.W.1.
A. MUIRHEAD,
Managing Director.
91, Petty France, S.W.1.
25th March, 1924. D 331

APPOINTMENTS OPEN.

UNIVERSITY COLLEGE OF SWANSEA.

The Council invites

Applications for the Post of

ASSISTANT LECTURER in Metallurgy. Salary, £300 per annum. The appointment will date from the 22nd April, 1924.
Further particulars may be obtained from the undersigned, by whom applications must be received on or before the 31st March 1924.
EDWIN DREW,
Registrar.
Singleton Park, Swansea. D 242

The Government of India

REQUIRE an
OIL ENGINE INSPECTOR
for the Military Engineer Services.

Three years' agreement, extensible to five years. Pay and allowances Rs. 750 per mensem consolidated. Free passage to India for self and family, if any, and return passages on satisfactory termination of services. Candidates must have served a full apprenticeship in the works of a well-known oil engine manufacturer of the largest size of Semi-Diesel oil engines, and have had subsequent practical experience in setting up and maintaining oil engines, including those of the latest cold starting type, A.M.I.C.E. or A.M.I.Mech.E. preferred.
Detailed applications will be received, not later than 14th April, 1924, by the SECRETARY to the HIGH COMMISSIONER FOR INDIA, 42, Grosvenor Gardens, London, S.W. 1, from whom further particulars may be obtained. D 294

ADMINISTRATIVE COUNTY OF LONDON.

HEATING AND VENTILATION.

Assistants With Good Tech-

nical Education are REQUIRED for temporary engagements in the Architect's Department of the London County Council. Candidates must be experienced in designing modern heating (low pressure) and ventilating schemes and in supervising the execution of the work. The rates of pay will be according to qualifications but not exceeding £6 10s. a week. Preference will be given to persons who have served, or attempted to serve, with the forces of the Crown.
Application Forms can be obtained from the Architect to the Council, The County Hall, Westminster Bridge, S.E.1. Canvassing disqualifies.
JAMES BIRD, D 290
Clerk of the London County Council.

Works Manager Wanted for

Hosiery Machine Building Works. Must be first-class man. State qualifications and salary required. (Confidential.)—Address, D 296, Offices of ENGINEERING.

INSTITUTION OF CHEMICAL ENGINEERS.

Assistant Secretary Wanted,

to act also as Assistant Secretary of the Chemical Engineering Group of the Society of Chemical Industry. Age, 30-38. Must be tactful, good organiser, have some scientific knowledge and also experience of Office routine and the keeping of accounts.—Apply, by letter only, not later than April 12th, 1924, stating qualifications, experience, salary required, and giving three references, to the INSTITUTION OF CHEMICAL ENGINEERS, 307, Abbey House, Victoria Street, London, S.W.1. D 331

Wanted, for the Period of

British Empire Exhibition, a YOUNG MAN to attend to Exhibit by Electrical Motor Manufacturing Firm. Salesmanship ability essential. State age, experience, and salary required.—Address, D 305, Offices of ENGINEERING.

The Royal Air Force

REQUIRES ELECTRICIANS, WIRELESS OPERATORS and POWER STATION TRADESMEN. Age limits: ex-service men 18 to 30; non ex-service 18 to 26. Pay from 24s. 6d. to 33s. 6d. per week on enlistment, and all found. Allowance for wife and children to men 26 and over.—Write, stating age, or call—INSPECTOR OF RECRUITING, R.A.F., 4, Henrietta Street, Covent Garden, London, W.C.2. C 969

Wanted by a British Company

for its Railway in Chile, a Competent CIVIL ENGINEER, with a good mechanical engineering training, to act as Assistant to General Manager. Must be a Member or Associate of Institute of Civil Engineers. Thorough knowledge of Spanish essential. Age 35 to 40. Free furnished house provided. Commencing salary £1,200 per annum. Four years' contract.—Write, "C.E.R." c/o STREETS, 6, Gracechurch St., London, E.C.3. D 328

Sales Engineer Wanted by a

well-known firm who both manufacture and sell special lubricants.
Applicants must have had training in mechanical engineering. Position should offer prospects for suitable applicant. Age 25-30.
Address, D 289, Offices of ENGINEERING.

Engineer (Mechanical) Re-

QUIRED as Active Director in London Company, with full-time occupation. Investment £2000. Salary £520 p.a. plus share of profits. Open to Solicitors' and Accountants' investigation.—Write, BOX B 4943, FRANCIS & CO., 131, Fleet Street, E.C.4. D 276

Assistant Engineer.—

Applicants are informed that the position advertised on 29th February under Box No. D 19, has been filled. D 286

Applicants for the Position of

Chief Assistant Engineer C 976 are advised that the Appointment is now filled. D 285

Engineer Required with Good

technical and practical training, including knowledge of Chemistry, to act as Engineer-in-charge of Chemical Plant. Age not over 30. Apply stating full experience and salary required.—Address ENGINEER, WM. PORTEOUS & CO., Advertising Agents, Glasgow. D 344

GREAT INDIAN PENINSULA RAILWAY.

The Directors are prepared to receive

Applications from Candidates

trained in LOCOMOTIVE ENGINEERING, for APPOINTMENTS as ASSISTANT SUPERINTENDENTS (Officers grade) in the Transportation Department of the above Railway in India.
Candidates should be from 24 to 30 years of age, and preferably unmarried.
Appointments are for three years under agreement in the first instance, which may be subsequently extended by arrangement. The Company will provide first-class passages to India.
Candidates must have had first-class general and technical education, and have been fully trained in Locomotive Engineering in Railway Locomotive Works or in the Works of a Locomotive Manufacturer, and must have had subsequent experience in Railway Running Shed Locomotive Repairs and in Locomotive Firing. Amongst further qualifications which Candidates may possess, some knowledge of Electrical Work, Telephonic Traffic Control, Block System of Signalling, and of the principles of interlocking points and signals will be advantageous.
Initial salaries will ordinarily be the minimum of the incremental Scale which may be seen in the Company's Office, ranging from Rupees 450 to Rupees 1150 per mensem, but initial salaries may be higher if specially qualified men are selected. Increments are granted after each year of approved service up to the maximum stated above.
Leave will be granted at the discretion of the Company in accordance with the rules which may be seen in the Company's Office. Leave cannot be claimed as a right.
Selected Candidates will be required to pass a Medical examination by the Company's Consulting Physician before appointment.
Applications for appointment must be made on Forms which must be obtained, by written request, from Messrs. ROBERT WHITE & PARTNERS, 3, Victoria Street, London, S.W. 1, the Consulting Engineers to the Company, and to whom the Forms must be returned after completion.
With the Application Forms will be forwarded brief particulars of the Railway Provident Fund. D 293

Locomotive Draughtsman.—

First-class Leading Hand, REQUIRED for large Works near Manchester.—Address in confidence, stating age, experience and salary, D 271, Offices of ENGINEERING.

, 1924.

nted for
rks. Must be
s and salary
296, Offices of

NGINEERS.

Wanted,
etary of the
e Society of
at be tactful,
owledge and
he keeping of
t later than
, experience,
ences, to the
NGINEERS,
ndon, S.W. 1
D 818

eriod of
a YOUNG
trical Mech
hip ability
and salary
NGINEERING

Force
ANS, WIRE
ER STATION
e men 18 to
m 24s. 6d. to
all found.
26 and over.
HCTOR OF
rect, Covent
C 965

ompany
Competent
mechanical
t to General
Associate of
knowledge
e furnished
£1,200 per
"C.E.E." c/o
.C.3. D 338

d by a
facture and

mechanical
rospects for

g.

d) Re-
in London
investment
fits. Open
on.—Write,
reet, E.C.4.
D 276

eer.—
he position
No. D 19,
D 288

tion of
are advised.
D 289

n Good
including
ngineer-in-
30. Apply
required.
& Co.,
D 344

LWAY.

ive
idates
EERING,
SUPER-
sportation
s.
rs of age,

greement
sequently
pany will

neral and
trained in
comotive
ufacturer,
rience in
irs and in
lifications
wledge of
ol, Block
ciples of
ntageous.
minimum
en in the
to Rupees
he higher
crements
ervice up

on of the
hich may
annot be

to pass a
nsulting

made on
request,
TN EERS,
nsulting
om the

rwarded
s Fund.
D 293

m.—
ED for
ndence,
ffices of

THE PROPERTIES OF GASES IN HIGH AND LOW VACUA.

AT the Royal Institution on Saturday afternoon last Sir Ernest Rutherford, F.R.S., delivered the third lecture of his course on the above subject.

He said that on the last occasion he had given an account of the more modern forms of rapidly exhausting pumps and had demonstrated how rapidly exhaustion proceeded with them. As then stated, there was theoretically no limit to the degree of exhaustion, but in practice some occluded gases were always liberated from the walls of the vessel evacuated. Moreover, if the very lowest pressures were to be obtained it was necessary to include a mercury vapour trap in the tubing between pump and vessel. This generally consisted of a branch tube containing charcoal immersed in a vessel of liquid air. In this vessel was condensed any mercury vapour which diffused from the pump. He had shown in the preceding lecture that with these pumps it was possible to have widely different pressures in two vessels connected together by a fine tube. This was at times of great value, especially when an electric discharge was to be produced at one pressure and examined at another. This was necessary in the positive ray investigations of Sir J. J. Thomson and Dr. Aston, and, in their experiments, had been secured by having a capillary passage between the two parts of the discharge tube used, and by fitting the low-pressure section with a side tube containing charcoal which could be immersed in liquid air.

In other cases, however, the modern rapidly exhausting pumps were required, and six of them connected in parallel had been used by Professor Wien for maintaining the required low pressure in the positive ray section of the apparatus used by him in measuring the duration of the luminosity of these rays. From these experiments Wien concluded that the duration of the luminosity of a positive particle was between 10^{-7} and 10^{-8} seconds.

After repeating an experiment due to the late Sir James Dewar, which showed that when a stream of gas flowed from one vessel into another it retained its individuality as a jet unless the pressure in the receiver was extremely low or the speed of the jet extremely high, Sir Ernest proceeded to discuss various methods of measuring very low pressures.

Having briefly described the tilting mercury gauge used about the year 1900 by the late Lord Rayleigh in his precise experiments on the validity of Boyle's law at low pressures, Sir Ernest said that for ordinary work in which the experimenter was pleased to secure an accuracy of the order of 1 per cent., the well-known Macleod gauge, introduced in 1874, was very generally adopted. In this gauge the gas, the pressure of which was to be measured, was compressed from a large vessel of known capacity into a capillary tube. By this operation the original pressure of the gas could at need be magnified some 10,000 times. Purists objected to this gauge because if any condensible vapours were present, the pressure due to these could not be measured, but only the pressure due to permanent gases. Nevertheless, under suitable conditions the Macleod gauge afforded the simplest and one of the best methods for approximate measurements of gas pressures from 2 mm. to $\frac{1}{1,000}$ mm. of mercury. In fact, with certain gases it was possible to measure pressures down to $\frac{1}{100,000}$ mm. with an accuracy of 1 per cent. It might also be noted that even those who most strongly emphasised the defects of this gauge, invariably used it for calibrating the alternative forms of gauge they recommended.

Of the methods which could be used for measuring extremely low pressures some of the best had been developed from the Crookes' radiometer, which was invented some fifty years ago. The general theory of the motion of the radiometer vanes had been given by Schuster, Maxwell and Osborne Reynolds. They showed generally that the motion of the vane was due to the presence of rarefied air, and were able to account for the fact that with certain arrangements the motion of the vanes was towards the light and in others away from it. During the last ten years, however, the subject had been quantatively developed by Professor Knudsen of Copenhagen, and his results constituted the basis of certain instruments for measuring very low pressures.

Professor Knudsen calculated the repulsion which would be exerted between a hot and a cold plate mounted in an expanded bulb, and had tested his results experimentally.

Suppose we had a hot plate and a cold plate arranged parallel to each other in an exhausted space at a fairly low pressure, and suppose this pressure could be varied at will, if the pressure were extremely low, the mean free path of the air molecules would be very long in comparison with the distance between the plates. It might, for example, be 10 cm., whilst the plates might be, say, a few millimetres apart. There was a repulsion between a hot plate and a cold plate thus mounted which over a wide range was directly proportional to the gas pressure in the bulb. This rule held down to pressures of 10^{-5} mm. The repulsion arose because both sides of each plate were bombarded by molecules. The molecules that came from the hot plate had, however, a higher speed than those which struck the other side of the cold plate.

In order to measure this effect Knudsen used the apparatus indicated diagrammatically in Fig. 7. In this BB represented two fixed plates which could be heated, and AA cold plates hung from a quartz fibre. The repulsion arising, as explained above, deflected the frame carrying the cold plates AA, and this deflection was measured by a beam of light reflected from the mirror M. From his theoretical

Fig. 7. DIAGRAM OF KNUDSEN GAUGE

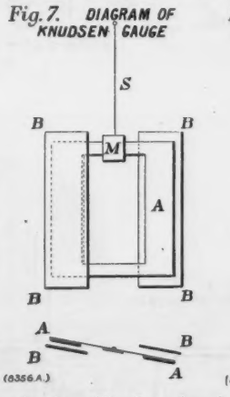


Fig. 8. QUARTZ FIBRE GAUGE

investigations Knudsen found that the repelling force between the plates was given by the formula

$$R = \frac{p}{2}\sqrt{\frac{T_1}{T_2} - 1}$$

where R denoted the repulsion per square centimetre of one plate, p the pressure of the rarefied gas, whilst T_1 denoted the absolute temperature of the hot plate and T_2 that of the cold plate. It would be seen from this formula that the hotter the hot plate the greater the repulsion. Knudsen verified this law by careful experiment, and on his results a manometer for the measurement of low pressures could be based, the instrument being calibrated by the Macleod gauge.

Another method of measuring low pressures was based on the gas friction. As was well known, if we had two parallel surfaces separated by a layer of fluid, then if one surface was moved relatively to the other this motion would be resisted by a force proportional to the viscosity of the fluid, to the speed of the motion, and inversely proportional to the distance separating the two surfaces.

Maxwell had predicted from theory that the frictional drag would be independent of the pressure over a very wide range, and had proved his conclusion by direct experiment. This was in fact the first great triumph of the kinetic theory of gases. The rule held down to an air pressure of 1 mm. of mercury, but as Maxwell had foreseen, it broke down when the mean free path of the gas molecules was so large compared with the distance between the plates that the molecules made very few collisions with each other in comparison with the number they made with the plates. Hence, with pressures such as $\frac{1}{10}$ to $\frac{1}{100}$ mm. the law expressing the friction between a fluid and a solid was entirely different to that which ruled at higher pressures. This, Sir Ernest demonstrated with the decrement gauge represented in Fig. 8. This consisted, he said, of a fragment of iron supported by a quartz fibre. This could be deflected by means of a magnet and when the magnet was removed the fibre sprung back and vibrated. The rate of dying away of these vibrations afforded a measure of very low pressures. At higher pressures, the damping out of the vibrations was independent of the pressure.

A third method of measuring low pressures was based on the rate at which heat was carried off from a hot wire by the molecules of the gas surrounding it. The arrangement was known as a Pirani gauge.

The gauge was made by mounting a lamp filament in a bulb. This filament formed one arm of a wheatstone bridge. Its resistance varied with its temperature, and this temperature depended upon the rate at which heat was carried away from the hot wire by the gas molecules impinging on it. Over a wide range the heat conductivity of the gas was independent of the pressure, but at low pressures this was no longer the case, and hence the arrangement could be used as a pressure gauge.

Each molecule striking the wire did so with a certain average momentum, but if the wire was hot it went away again from the surface with a higher velocity than what it had at impact. Energy was thus carried away in proportion to the number of molecules colliding with the wire.

An important point which arose in this connection was whether every molecule acquired the temperature of the wire before rebounding. If the surface were infinitely rough so that it made many impacts before getting clear, the molecule would ultimately leave with the velocity corresponding to the temperature of the wire. In actual fact, however, the experimental evidence led to the conclusion that on the average the molecules left at a lower velocity than this.

THE POWER STATION OF THE BRITISH EMPIRE EXHIBITION.

(*Continued from page* 364.)

IN our previous articles we have dealt in considerable detail with the boiler-house of the Wembley power station and its principal equipment. The whole power-house, as will be seen from the photographs we reproduce this week on our two-page plate, is well advanced towards completion. We understand, indeed, that the work is a week or more ahead of the schedule of progress—a fact which must be as satisfactory to Mr. E. H. Parsons, the engineer to the Exhibition, as it is creditable to him. Fig. 28, on Plate XXVII, is a view of the boiler-house taken from the Machinery Hall, and it shows how well the visitors will be able to observe the plant in operation. The two boilers at the right are those supplied by Messrs. Babcock and Wilcox, Limited, and, as will be seen, they, as well as the further pair by Messrs. John Thompson Water Tube Boilers, Limited, are each fitted with Avery automatic scales, so that the weight of coal passing from the overhead concrete bunkers to each stoker will be automatically recorded. Fig. 29, on the same plate, is a photograph taken from the end of the boiler-house nearest to the turbine room. The tops of the John Thompson boilers under erection are seen in the foreground, and on the right is the wall of the concrete coal bunker.

The engine-room, as already explained and as shown in the key plan, Fig. 2, page 331 *ante*, is situated at the end of the boiler-room, and is so arranged that the running machinery is in full view of the visitors to the Machinery Hall, while for those who desire to make a closer inspection a raised gallery is provided. Fig. 30, Plate XXVII, is a view taken from one end of this gallery. The engine-room contains three 1,500-kw. 3,000-rev. turbo-alternators, producing three-phase current at 3,300 volts and 50 cycles. The set shown in the foreground is of the English Electric Company's manufacture throughout, and, as will be seen, is in an advanced stage of erection. The central set consists of a turbine by Messrs. James Howden and Co., Limited, driving an alternator by the

General Electric Company, Limited, and exhausting into a condensing plant by Messrs. John Musgrave and Sons, Limited. In the background, next to the wall of the boiler-room, is a turbine and alternator by the British Thomson-Houston Company, Limited, with a condensing plant by Messrs. Cole, Marchant and Morley. The erection of this set was complete at the time the photograph was taken. The ironclad Reyrolle switch-gear, against the north wall of the engine-room, and the large condenser pits, in which the auxiliaries are in full view from the turbine-room floor, will also be noted. The crane serving the engine-room is one of 25 tons capacity, supplied by Messrs. Babcock and Wilcox, Limited.

In Fig. 31, Plate XXVII, is shown a view of the 1,500-kw. British Thomson-Houston turbo-alternator, taken at the works before dispatch to Wembley. The lay-out of this set is illustrated in Figs. 32 to 34, on this and the opposite page, while in Fig. 35, on the latter page, is shown a view of the turbine alone, with the top half of the casing removed. Sectional drawings of the turbine and generator are given in Figs. 36 and 37, page 390, and particulars of the Cole, Marchant and Morley condensing plant, which serves the turbine, are given in Figs. 38 to 42, on page 391. As will be seen from Figs. 32 to 34, the condenser is placed cross-wise beneath the turbine, with the circulating pump and condensate pump at the end, where they are not only in full view of the attendant, but are also accessible to the overhead crane. The turbine, which works with steam at a pressure of 200 lb. per square inch, superheated to 600 deg. F., and exhausts into a vacuum of 28 in., has seven stages, the first wheel being of the velocity-compounded type and all the rest single-impulse wheels. The steam passing to the nozzles to the first stage is controlled by the cam arrangement of the British Thomson-Houston Company, which was fully illustrated and explained in connection with our description of the 30,000-kw. turbine which this company recently supplied to the Rotherham Corporation. It is interesting to note that in the Wembley turbine the whole of the nozzles and blading are made of stainless steel.

It will be seen from Fig. 36 that provision is made in the casing for passing out a certain proportion of the steam after it has done work on the first four wheels. This is in accordance with the practice of heating feed water by steam withdrawn in this way, which is not only theoretically advantageous to the overall thermal efficiency, but has been found to give substantial economy in actual use. Incidentally, moreover, the reduced volume of steam required to be handled by the low-pressure blading is an advantage in design. The machine at Wembley is not fitted with a pass-out feed-water heater, the connection being blanked off. The rotor is located axially by a thrust block consisting of a split cast-iron sleeve lined with white metal and machined internally to fit collars and grooves turned directly on the turbine shaft. The thrust block is carried by an extension of the inlet end bearing, and its axial position is determined by a screw thread. The thrust block can be rotated by a worm gear controlled from the outside of the bearing pedestal, so that the clearance may be adjusted while the machine is running. The adjusting gear is provided with a locking device to prevent unauthorised interference.

The glands at both ends of the turbine consist of segmental carbon packing rings held together by means of garter springs. A steam seal maintains the space inside the outer ring always at a pressure slightly above that of the atmosphere, so that there is no chance of air leaking inwards. The glands are removable without disturbance to the rest of the turbine. The coupling, as in all three-bearing units, is solid, and is made by flanges formed on the shaft ends of the turbine and generator respectively. The wheels are forced by hydraulic pressure over bronze bushes on the turbine shaft. These bushes enable heavy force fits to be used and entirely prevent the wheels becoming loose in service. The diaphragms between the wheels are rigid castings, made in halves with a grooved and tongued joint on the horizontal division. They are also registered axially by grooves and tongues around the periphery,

EMPIRE EXHIBITION; 1,500-KW. TURBO-GENERATOR.

Fig. 32.

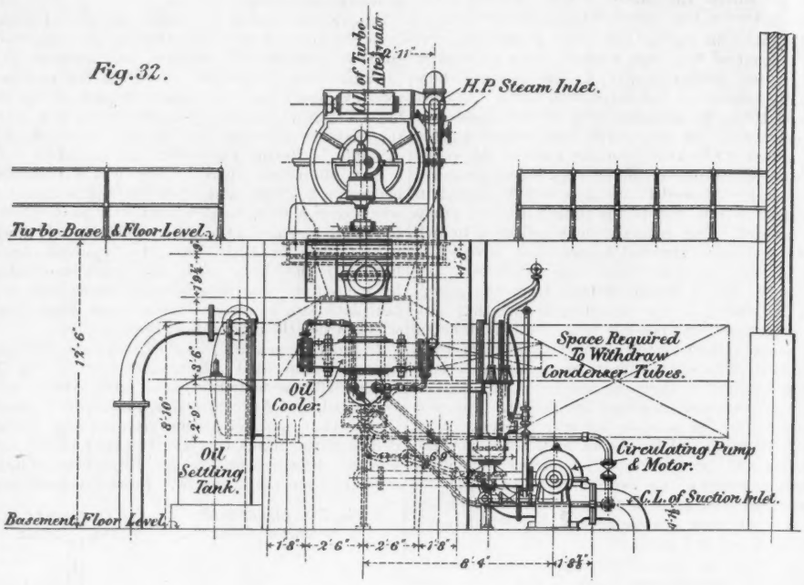
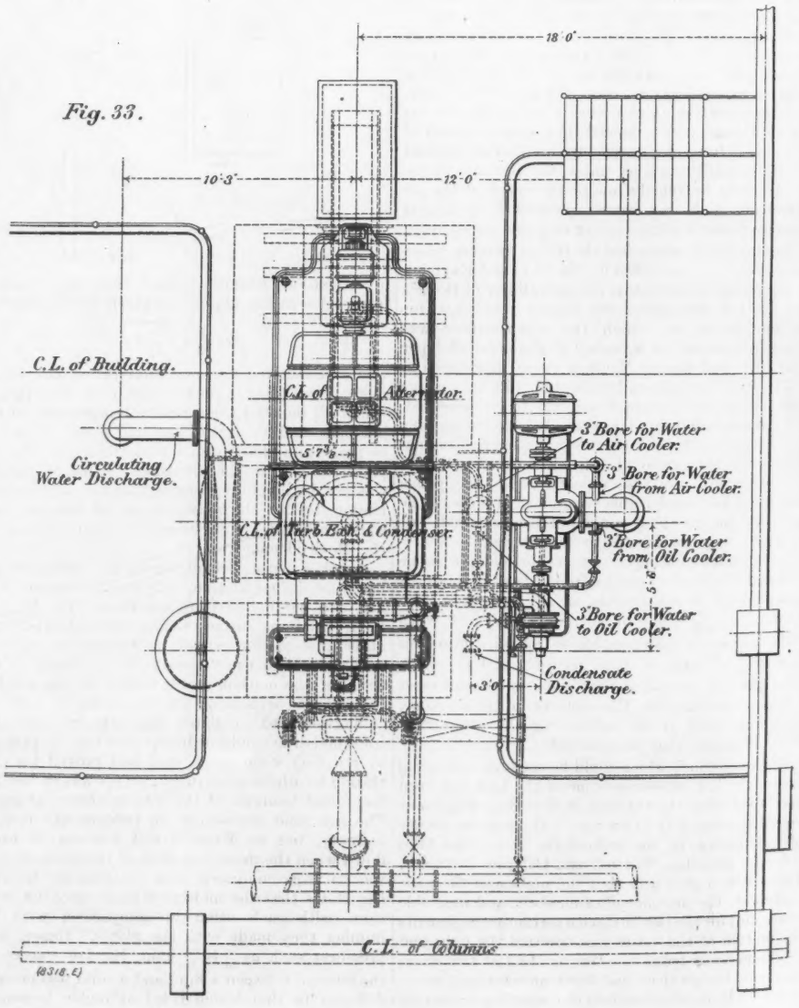
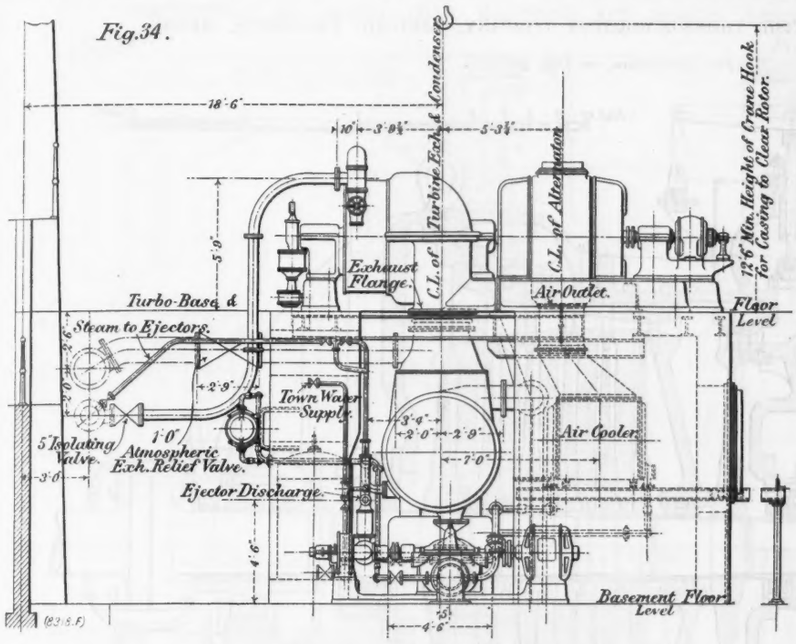


Fig. 33.


C.L. of Building.
C.L. of Alternator.
Circulating Water Discharge.
3" Bore for Water to Air Cooler.
3" Bore for Water from Air Cooler.
C.L. of Turb. Exh. & Condenser.
3" Bore for Water from Oil Cooler.
3" Bore for Water to Oil Cooler.
Condensate Discharge.
C.L. of Columns.

EMPIRE EXHIBITION; 1,500-KW. TURBO-GENERATOR.



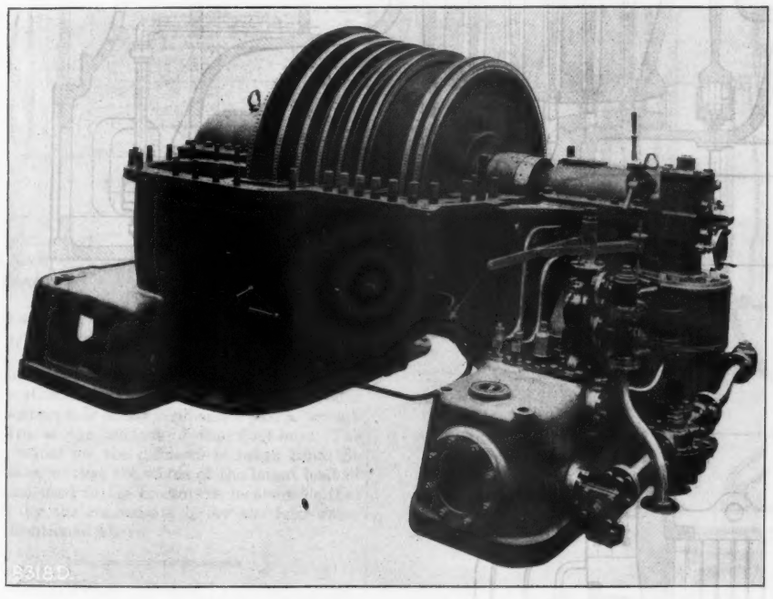


FIG. 35. 1,500-KW. B.T.-H. TURBINE WITH TOP OF CASING REMOVED.

and are further secured against rotation by means of set-screws.

The bearings are spherically sealed and self-aligning, with white-metal bearing surfaces. They are lubricated by oil under pressure and are fitted in addition with oil rings. The low-pressure bearing is provided with the firm's patent damping device to avoid vibration. Oil for lubricating is supplied under pressure by a rotary pump driven from the lower end of the governor shaft. The oil is cooled by an oil cooler on its way to the bearings. The cooler consists of a cast-iron casing with straight-beam tubes, through which the water circulates. The tube ends are fixed by means of Admiralty ferrules in brass tube plates, and the tubes can be cleaned or withdrawn without breaking any oil or water joints.

The generator is designed for a continuous output of 1,875 kilo volt-amperes at 80 per cent. power factor, and 3,300 volts between terminals. The speed, as already stated, is 3,000 revolutions per minute, and the current three-phase at 50 cycles. The maximum temperature rise after a continuous run under full-load conditions will not exceed 40 deg. C. for the stator and 75 deg. C. for the rotor. The machine is also capable of an overload of 25 per cent. for two hours, or an output of 2,344 kilo volt-amperes at 80 per cent. power factor. If the alternator be run at this overload for two hours immediately following the full-load run, the stator temperature and the rotor temperature will not exceed 55 deg. C. and 90 deg. C. respectively. Where the alternator is controlled by a Tirrell automatic regulator, as is the case at Wembley, the permanent voltage variation or voltage rise from full load to no load at 80 per cent. power factor will not exceed 1 per cent. and the momentary variation will not exceed 5 per cent.

The steam consumption of the set at 28-inch vacuum is guaranteed at the following figures; 25 per cent. overload 13·0 lb. per kilo watt-hour: full load, 13·1 lb.; three-quarters full load, 13·6 lb. and half full load, 14·62 lb. per kilo watt-hour. The total weight of the turbine and alternator is 28 tons, and the heaviest parts to be handled during erection is 7 tons.

The alternator is arranged for ventilation on the closed air system, an air cooler of the British Thomson-Houston Company's type being installed, as shown in Fig. 34. The air cooler consists of a framework containing a number of straight brass tubes fixed into heavy rolled brass tube plates, and provided with water boxes at the ends, similar in many respects to a surface condenser. The air discharged from the alternator passes round the outside of the tubes and the cooling water through the tubes. The quantity of cooling water required is about 85 gallons per minute at a temperature of 75 deg. F., and at a head of 10 ft. This water is drawn from the circulating system of the condenser. The cooler is placed between the alternator foundations, and hand-operated dampers are fitted to enable the cooler to be put out of service and the alternator to work with fresh air. A thermostatic device is also provided to give an alarm when the air temperature exceeds a predetermined limit.

The exciter, which, as shown in Fig. 37, is flexibly coupled to the end of the alternator shaft, is mounted on an extension of the outboard pedestal of the alternator. It is shunt wound and is provided with commutating poles. The field coils are wound on metallic bobbins and are held in position by the projecting pole tips. The ends of the armature windings are mounted on solid flanges, which, with the outer covering of binding wire, ensure that they are totally enclosed and are, therefore, inaccessible to dust or dirt. Only the working surface of the commutator is exposed.

The general arrangement of the Cole, Marchant and Morley condensing plant is shown in Figs. 38 to 42 on page 391. The condenser itself is of the firm's standard design with brass tubes and tube plates. The spacing of the tubes is so arranged as to provide a progressively narrower passage for the steam as it becomes condensed, thus maintaining its velocity past the cooling surfaces. The auxiliaries comprise a centrifugal circulating pump and a centrifugal condensate pump placed in line on a common bedplate and driven directly by an electric motor on the same bedplate. The removal of air is effected by a Delas air-ejector, also constructed by Messrs. Cole, Marchant and Morley, Limited. The general appearance of this apparatus is shown in Fig. 42, while the sectional drawing, Fig. 41, illustrates its construction. It consists essentially of two ejectors working in series, its special feature being the water-jacketing of the ejector tubes, which renders the action of the apparatus stable under variable conditions of working. The two ejectors are arranged side by side in a cast-iron casing. Air and vapour from the condenser enters the apparatus through the branch on the left-hand side of Fig. 41. The mixture is entrained by the jet of steam issuing at high velocity from the divergent nozzle of the first stage, and is driven through the diffuser tube into the central chamber, being raised in pressure by the process. Water is circulated round both diffuser tubes, entering at the tapped branch on the right-hand side of Fig. 41, passing first round the secondary diffuser, then round the primary diffuser, and finally acting as injection water to condense the steam coming from the primary ejector nozzle.

A minute examination of Fig. 41 will show small holes through the tapered shoulder near the lower end of the primary diffuser. The water from the diffuser jacket passes through these holes, and condenses the steam from the primary nozzle by direct contact. The air passes through the intermediate chamber to the secondary ejector, by which it is finally discharged at atmospheric pressure through the branch shown in Fig. 41 into the feed-water heater, where the ejector-steam is condensed and the air liberated. At the bottom of the extractor casting is a float-box, containing a vacuum sealing device, which is rendered necessary by the difference between the main condenser pressure and the central chamber of the extractor.

BRITISH EMPIRE EXHIBITION; 1,500-KW. TURBINE AND ALTERNATOR.

CONSTRUCTED BY THE BRITISH THOMSON-HOUSTON COMPANY, LIMITED, ENGINEERS, RUGBY.

(*For Description, see Page* 387.)

Fig. 36.

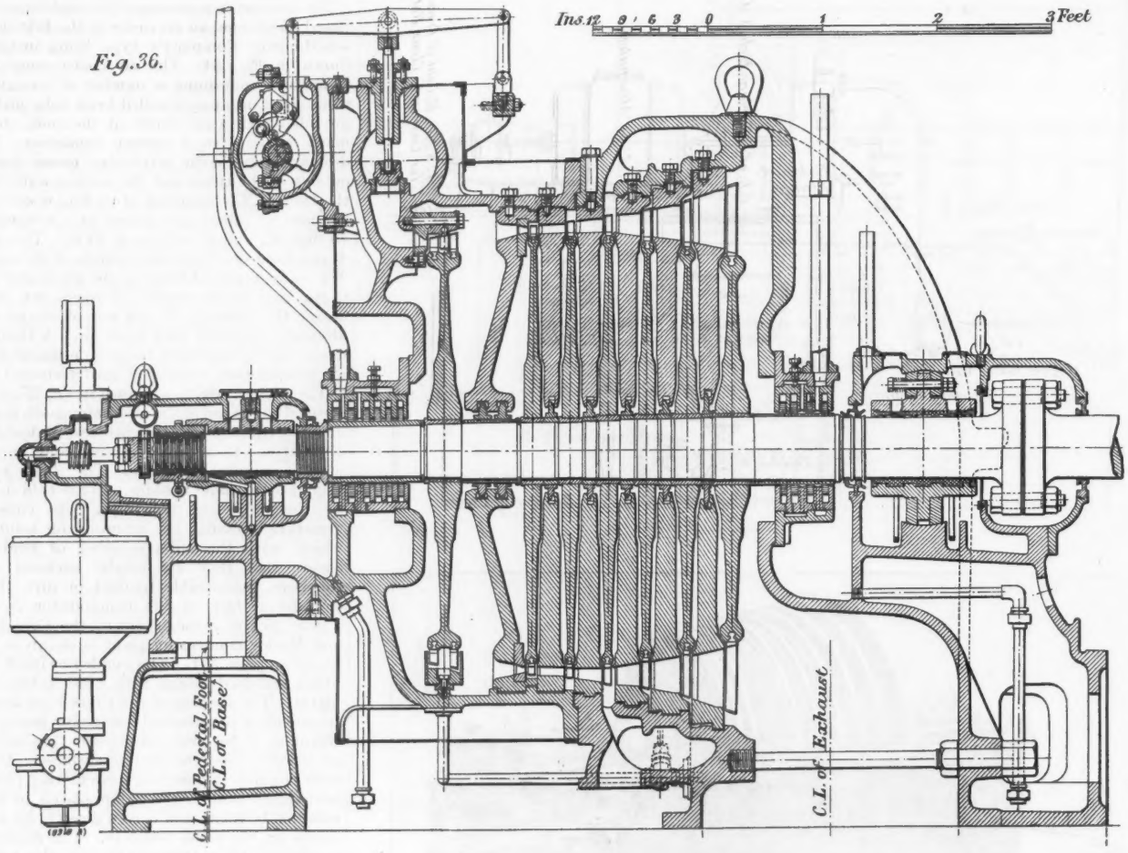
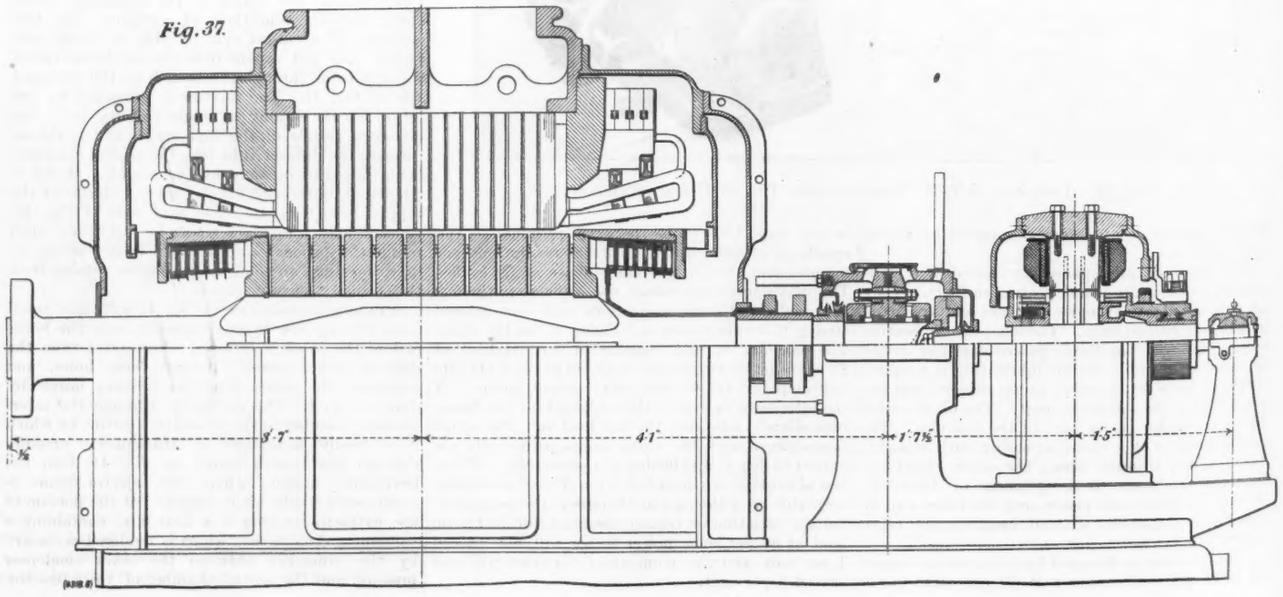


Fig. 37.



BRITISH EMPIRE EXHIBITION POWER STATION; CONDENSING PLANT.

CONSTRUCTED BY MESSRS. COLE, MARCHENT AND MORLEY, LIMITED, ENGINEERS, BRADFORD.

Fig. 38.

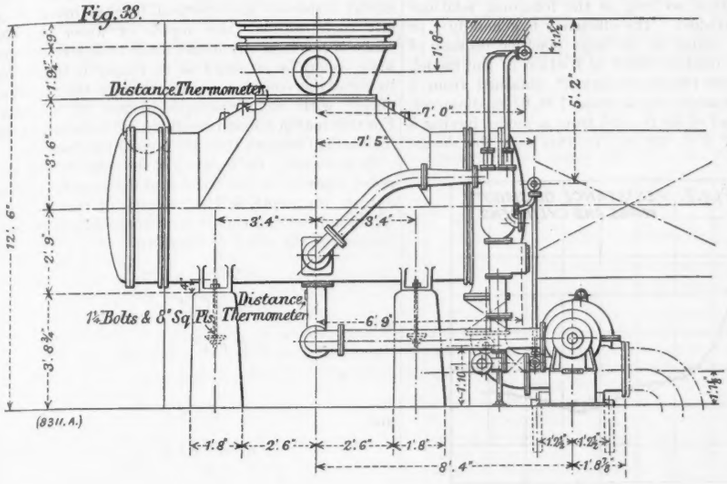


Fig. 39.

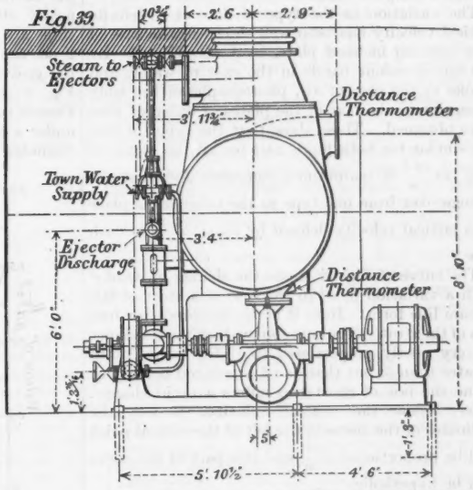


Fig. 40.

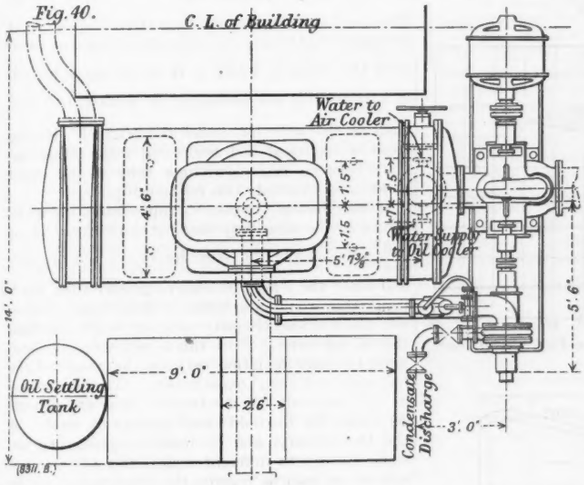


Fig. 41.

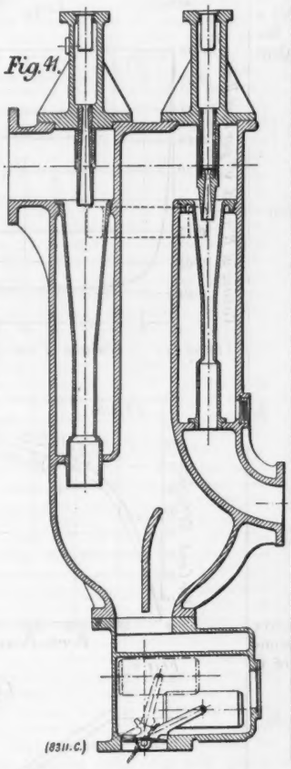


FIG. 42.

The condensed steam from the primary ejector, together with the water which condensed it, flow to the suction side of the condensate pump through the valve at the bottom of the float-box. The cooling water for the diffusers is taken from the condensate, so that the whole of the latent heat of the steam used in the ejectors is recovered either directly by the condensate or by the feed-water heater mentioned above.

THE PRINCIPLE OF DYNAMICAL SIMILARITY, WITH SPECIAL REFERENCE TO MODEL EXPERIMENTS.

By Professor A. H. GIBSON, D.Sc., M.Inst.C.E.

(Continued from page 359.)

13. *Resistance of Smooth Wires and Cylinders.*—A somewhat similar scale effect is obtained from experiments on the resistance of smooth wires and cylinders. A series of such tests on a range of diameters from 0·002 in. to 1·25 in. with v ranging from 10 to 50 f.s.,* shows that on plotting $R/\rho\, v^2 d^2$ against $\frac{v\,d}{\nu}$, or log $\frac{v\,d}{\nu}$, a narrow band of points is obtained which include all the experimental results (Fig. 3). This shows that for a given value of $\frac{v\,d}{\nu}$ the value of $R/\rho\, d^2 v^2$ is the same for all values of v and of d. From this it appears that whereas experiments on a single wire or cylinder indicate that R is nearly proportional to v^2, true similarity of flow is only obtained when $\frac{v\,d}{\nu}$ is constant.

If, in a curve of this type, the ordinates do not vary greatly with $\frac{v\,d}{\nu}$, the motions may be said to be nearly similar. If the variation is large, the value of model results is reduced. The scale correction is large, and for accurate results it becomes necessary to carry out model experiments over the whole range of $\frac{v\,d}{\nu}$ to be covered by the original.

It becomes very necessary to satisfy this condition with comparatively low values of $\frac{v\,d}{\nu}$, owing to the changes which may occur in the type of flow around such bodies at comparatively low velocities, or with small diameters. As in all other cases of flow, as this factor is reduced a critical value is ultimately reached where the type of flow undergoes a definite and rapid change, so that the function ϕ ceases to be even approximately constant.

For a given body in a given medium, this critical value of $\frac{v\,d}{\nu}$ corresponds to a critical speed, which may be calculated from the values of d and ν, if its value has once been experimentally determined for bodies of the given form by varying any one of the variables d, v and ν.

In some bodies such as spheres and cylinders, the law of resistance may change widely, with comparatively small alteration in the conditions: thus, for example, at certain speeds the resistance of a sphere may actually be reduced by roughening the surface. In carrying out any such experiments therefore it is of the greatest importance that the geometrical

* Reports and Memoranda, Advisory Committee for Aeronautics, No. 40, March, 1913; No. 74, March, 1913; No. 102.

similarity between a model and its prototype should be as exact as possible, and that where possible $\frac{v\,d}{\nu}$ should be kept constant.

The variation in the type of flow at a definite critical velocity has been well shown in the case of flow past an inclined plate, by C. G. Eden.* By the aid of colour bands in the case of water, and smoke in the case of air, photographs of the eddy formation in the rear of the plates of different sizes were obtained. These show that the types of flow are similar for both fluids and for all the plates so long as $\frac{v\,l}{\nu}$ is maintained constant, and that the change over from one type to the other takes place at a critical velocity defined by $v_{\text{crit.}} \propto \frac{\nu}{l}$ in each case.

The curve of Fig. 4† shows the change in $R/\rho\,d\,v^2$ with a variation in vd in the case of a strut of fair stream line form. Here R is the resistance per foot run of the strut. The curve shows that the resistance is very nearly proportional to v^2 for values of vd greater than 5, but that as vd is reduced below this value the law of resistance suffers a rapid change. Since, below the critical velocity, $R \propto v$, the ordinates of the curve to the left of the critical point will be proportional to $\frac{1}{v}$, and this part of the curve will be hyperbolic.

14. *Pumps or Turbines.*—In similar pumps or turbines, if Q is the discharge, d the diameter, n the number of revolutions per minute, ρ the density of the fluid, and p the pressure equivalent to the working head, we have:—

$$F(Q, d, n, \rho, p) = 0$$

$$\therefore\ K_1 = d^x\,n^y\,\rho^z\,Q = \left[\frac{Q}{n\,d^3}\right]$$

$$K_2 = d'^{1}\,n^b\,\rho^c\,p = \left[\frac{p}{d^2\,n^2\,\rho}\right]$$

$$\therefore\ \psi\left[\frac{Q}{n\,d^3}\right]\left[\frac{p}{d^2\,n^2\,\rho}\right] = 1 \quad . \quad (22)$$

or since $p/\rho = g\,h$,

$$\psi\left[\frac{Q}{n\,d^3}\right]\left[\frac{g\,h}{d^2\,n^2}\right] = 1$$

or

$$\psi\left[\frac{Q}{d^2\sqrt{g\,h}}\right]\left[\frac{g\,h}{d^2\,n^2}\right] = 1$$

For similarity it is therefore necessary that

$$Q \propto d^2\sqrt{h}$$

$$n \propto \frac{\sqrt{h}}{d}$$

for both pump and model, or that

$$\frac{Q}{Q_m} = S^2\sqrt{\frac{h}{h_m}}$$

$$\frac{n}{n_m} = \frac{1}{S}\sqrt{\frac{h}{h_m}}$$

where S is the scale ratio of original and model.

If T be the torque on the shaft, the horse-power P is proportional to $T\,n$, and is of dimensions $M\,L^2\,T^{-3}$, and if this term be inserted in place of Q in the original relationship it leads to the result

$$\psi\left(\frac{P}{d^5\,n^3\,\rho}\right)\left(\frac{p}{d^2\,n^2\,\rho}\right) = 1 \quad . \quad . \quad (23)$$

Combining this with (22) gives

$$\psi\left(\frac{Q}{n\,d^3}\right)\left(\frac{p}{d^2\,n^2\,\rho}\right)\left(\frac{P}{d^5\,n^3\,\rho}\right) = 1 \quad . \quad (24)$$

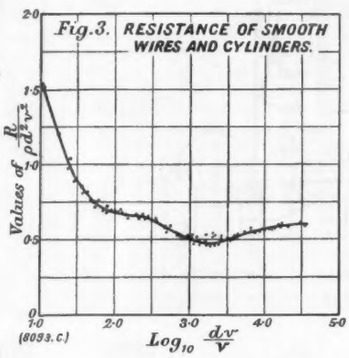
or, dividing the third term by the product of the first and second,

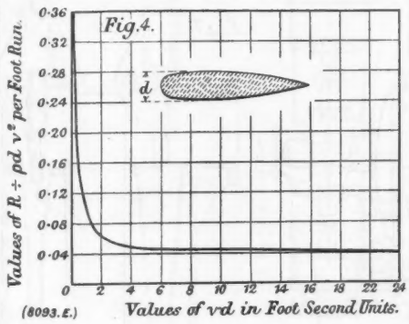
$$\psi\left[\frac{Q}{n\,d^3}\right]\left[\frac{p}{d^2\,n^2\,\rho}\right]\left[\frac{P}{Q\,p}\right] = 1 \quad . \quad (25)$$

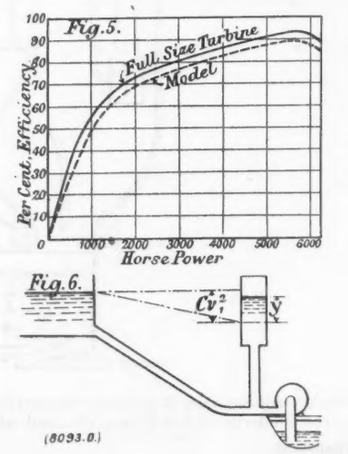
Since the last term is inversely proportional to the efficiency, the same similarity conditions will also lead to identical efficiencies, so that

$$\frac{P}{P_m} = S^2\left(\frac{h}{h_m}\right)^{\frac{3}{2}}$$

In this it has tacitly been assumed that the friction losses in the pump are proportional to v^2. If proportional to any other power of v, exact similarity will not be attained. Experimental evidence indicates, however, that if both the pump or turbine and its setting are similar for original and model, the characteristic curves, and efficiencies are very nearly identical so long as the foregoing relationships are satisfied. The efficiency is generally 1 or 2 per cent. higher in the large machine because of the greater relative effect of friction in the model. Fig. 5 shows efficiency curves* obtained from a Francis turbine having a runner 7 ft. 6¼ in. diameter, under a head of 49 ft. and from a model having a diameter of 2 ft. 3⅜ in. In this case the design of the setting in the large plant was better than in the model. With similar settings the coincidence between the two curves is usually closer than in this particular example.







It is to be noted that the model experiments may be carried out at any convenient head, and not necessarily at a head related to that at which the large machine is to operate in the ratio of corresponding linear dimensions.

15. *Estuary Model Experiments.*—As shown by Osborne Reynolds†, the action of the tidal ebb and flow, and of the river water in an estuary, on the formation of shoals, and the action of training walls in modifying such formations, can be reproduced with considerable accuracy under suitable conditions.

Owing to the great difference between the horizontal distances and vertical heights involved in any such original, the depths of water and the range of levels in any model made to any reasonable scale would be so small as to render it impossible to form the contours, or to measure the resultant effects with any reasonable degree of accuracy. For this reason a much smaller scale ratio is adopted for vertical heights than for horizontal distances.

In an estuary, the height y of the tidal wave at any point depends on the horizontal distance from some datum, the depth h, the velocity of travel of the wave, and on the time t from some datum instant. Neglecting the effect of viscosity

$$F(y/h, l, t, v) = 0$$

$$\therefore\ K_1 = l^x,\ t^y,\ v^z,\ y/h$$

or

$$l^x\,t^y\,l^z\,t^{-z} = \text{const.}$$

$$\therefore\ x + z = 0$$

$$y - z = 0$$

and

$$K_1 = \left[y/h\left(\frac{t\,v}{l}\right)^z\right] \quad . \quad . \quad (26)$$

For this to be dimensionless, $\frac{t\,v}{l}$ must be a constant, and since experiment shows that the velocity of propagation of a wave, whose length is large compared with the depth of water h, is proportional to $\sqrt{h}$, it is necessary, for similarity of motion, that $\frac{t\sqrt{h}}{l}$ shall be the same for model and original. Having fixed the vertical and horizontal scale ratios, the time between successive high tides in the model is adjusted to satisfy this relationship.

If the effect of viscosity is appreciable, it may be shown in the same way that for similarity, $l\,t\,\mu$, or $\frac{l^2\,\mu}{\sqrt{h}}$, must also be the same for model and original, and since the l ratio is always greater than the h ratio, this would necessitate a fluid being used in the model whose viscosity was very much less than that of sea water. Since this is impracticable there must be some deviation between the results of the full scale and model experiments. Whether serious or not can only be determined from experiment. As shown by Reynold's experiments on models of the Dee estuary, and on models representing the same estuary to different scales, this effect is not serious, at least as regards the development of the main features of the estuary, so long as the velocity in each case is above the "critical velocity," at which turbulent motion becomes stream line motion. Reynold's experiments indicate that so long as $r^3\,e$ is greater than 0·09, where r is the range of tide in feet, and e is the ratio of the horizontal and vertical scale ratios as compared with a 30 ft. tide, this condition is satisfied.*

16. *Surge Tanks.*—The problem of the surge tank, as fitted to water power installations in which the turbine is supplied from the forebay through a long closed pipe line (Fig. 6), gives rise to the simultaneous equations†

$$\frac{L}{g}\frac{d\,v}{d\,t} = y - C\,(v_1^n - v^n) \quad . \quad . \quad (27)$$

$$R\,\frac{d\,y}{d\,t} = v - v^1 \quad . \quad . \quad . \quad (28)$$

where L = length of pipe line.
R = ratio of sectional areas of surge tank and main.
C = coefficient such that loss of head in pipe line = $C\,v^n$.
v_1 = velocity in pipe line under steady flow before change of load.
v = velocity at any instant during change of load.
v^1 = velocity in pipe between surge tank and turbines at any instant.
y = height of water in stand pipe at any instant, above the level corresponding to steady flow with velocity v_1.

Even if the problem is reduced to its simplest form by making the assumptions that the loss of head in the pipe line is proportional to v^2, and that any

* Tech. Report of Advisory Committee for Aeronautics, 1910–11, page 48,; also R. and M., No. 31, March, 1911.
† "Applied Aerodynamics," Bairstow. Longmans Green and Co., 1920, page 392.

* H. B. Taylor, *Gen. El. Review*, June, 1914.
† "Scientific Papers," vol. ii, page 326, 380, 482.

* *Ibid*, vol. ii, page 414.
† "Hydro-Electric Engineering," Gibson, page 190.

change in load is followed by an instantaneous change in the opening of the turbine gates which gives a flow proportional to the new demand, it is only possible to obtain a mathematical solution to these equations by making certain assumptions as to the instantaneous rate of flow up the surge chamber, which, in extreme cases, may be very far from correct. It is true that the problem may be solved by arithmetical integration, but this is a very tedious process. Moreover, when the action of the governor as affecting the rate and time of closing of the gates requires to be taken into account, this introduces factors of such complexity as are extremely difficult to take into account even by the method of arithmetical integration.

Such a problem is specially well adapted for experimental investigation by means of a model,* and the accuracy with which the behaviour of the water in the tank can be deduced, depends only on the accuracy with which it is possible to reproduce experimentally the action of the governor. In such an installation, if pipe friction is proportional to v^2 so that viscosity may be neglected, the height y depends on L, t, ρ, v, g, so that the original relationship becomes

$$F(l, t, \rho, v, g, y) = 0.$$

Taking l, t, ρ as our independent terms gives

$$K_1 = \left[\frac{t\,v}{l}\right]; \; K_2 = \left[\frac{t^2 g}{l}\right]; \; K_3 = \left[\frac{y}{l}\right]$$
$$\therefore \; \psi\left(\frac{t\,v}{l}\right)\left(\frac{t^2 g}{l}\right)\left(\frac{y}{l}\right) = 1 \quad . \quad (29)$$

so that if the original and the model are similar in every respect,

$$t \propto \sqrt{l}$$
$$v \propto \sqrt{l}$$

i.e., the velocities of flow in the model and the times to complete any movement of the valves, are to be less in the model than in the original, in the ratio of the square roots of corresponding linear dimensions. Owing to the length of the pipe line such a model would in general require to have a very large scale ratio, and this would give such a small range of movement in the surge tank as to render the accurate measurement of such movements one of some difficulty. Also, and of more importance, the friction loss in the pipe line is seldom proportional to v^2, but to $C\,v^n$ where n is usually between 1·85 and 1·90.

In practice then it is necessary to work with models having a smaller scale ratio for vertical than for horizontal distances, and to allow for the fact that the friction loss and therefore y, is equal to $C\,v^n$, where C is not the same for model and original, but can be measured for the model and computed for the original. For similarity of the motions in the surge tanks it is necessary now for the head due to acceleration in the pipe line to be proportional to y instead of to l, and since

$$R\,\frac{d\,y}{d\,t} \propto v$$

for R to be proportional to vt/y we thus require

$$\psi\left(\frac{t\,y}{v\,l}\right)\left(\frac{R\,y}{t\,v}\right) = 1$$

which is satisfied if

$$t = \frac{v\,l}{y} = \frac{l}{C\,v^{n-1}} \quad . \quad . \quad (30)$$

$$R = \frac{v\,t}{y} = \frac{v\,l}{C\,v^{n-1} \times C\,v^n} = \frac{l}{C^2\,v^{2n-2}} \quad (31)$$

Any convenient diameter can be chosen for the model pipe line and any convenient velocity ratio, or alternatively any convenient vertical scale, so long as the above relationship between the values of corresponding times and of R's are satisfied.

In practice a suitable horizontal scale, a convenient pipe diameter, and a convenient working velocity are chosen. The loss of head $C\,v^n$ in the model pipe line at this velocity is measured ($= y_m$). From a knowledge of the diameter and length of the projected pipe line, the value of $C\,v^n$ or y for this is computed.

The ratio of these y's gives the vertical scale of the model. The area of the model surge tank is then determined by the relationship

$$\frac{R_m}{R} = \frac{t_m\,v_m}{y_m} \cdot \frac{y}{t\,v} = \frac{l_m}{l}\,\frac{C^2\,v^{2n-2}}{C_m^2\,v_m^{2n-2}} \quad (32)$$

The time of opening or closing the gates, or of producing any given changes in the velocity of flow in the large pipe being known, the corresponding time for the model is made less in the ratio

$$\frac{t_m}{t} = \frac{l_m\,v_m\,y}{l\,v\,y_m} = \frac{l_m}{l}\,\frac{C\,v^{n-1}}{C_m\,v_m^{n-1}} \quad . \quad . \quad (33)$$

in which case the heights in the surge tanks at corresponding times will be in the ratio

$$\frac{y_m}{y} = \frac{C_m\,v_m^n}{C\,v^n} \quad . \quad . \quad . \quad (34)$$

(To be continued.)

THE FRENCH NAVY.

THE Minister of Marine introduced in the French Chamber about a year ago a Bill, the tenour of which was said to relate to the "second portion of the naval programme." Dealing with this subject, *Le Moniteur de la Flotte* states that so long as the "naval statute" is not agreed upon, there can be no question of executing "a programme," but only the putting in hand of a few units intended to replace as far as this can be done, other units which, by their age, are destined to be removed from the service in the course of the next few years.

The present-day French Fleet, already very low in quantity and quality according to our contemporary, consists of nine battleships (including three pre-Dreadnoughts); six armoured cruisers, 15 to 20 years old; five ex-German light cruisers, which have already reached or have exceeded half their estimated life; one ex-German destroyer; 41 torpedo boats, of which only 24 are of military value; 43 submarines, 20 of which are only suitable for coast defence. In ten years' time, taking into account the ships to be built according to the law of April 18, 1922, and likely to be completed in the course of 1925, there will remain in the service three battleships, on the eve of being struck off the list; three light cruisers; six destroyers; 12 torpedo boats; 23 submarines. Compared with the present Fleet, this means a decrease of six battleships; eight cruisers; 12 torpedo boats and 20 submarines, and an increase of six destroyers. This situation is a most serious one; it implies—should the assumptions prove realities—the practical disappearance of France from among the Naval Powers, and calls for urgency in the replacing of cancelled units.

This was precisely the aim of the Bill referred to in the foregoing. It dealt with the construction of six light cruisers; 15 destroyers; 24 torpedo boats; 34 submarines of which four were to be fleet submarines; and two mine-laying units, besides four oil fuel carrying vessels. These ships were to be built gradually over a period of six years, from 1925 to 1930, and were to involve an average annual expenditure of 300,000,000 francs down to 1932 inclusive. Following upon two amendments, one proposing to increase to 100 the number of submarines and the other to replace two of the fleet submarines by submarines of smaller tonnage, the Naval Committee, acting in agreement with the Minister of Marine, proposed to reduce to two the number of fleet submarines and to utilise the 6,000 tons thus rendered available for the construction of seven second class, mine-laying submarines. The first amendment could not be met owing, on the one hand, to the insufficiency of building facilities and, on the other, to financial considerations; but the Committee noted with satisfaction the desire of its authors for an increase in the country's means of defence and decided to reduce the original building dates, the new period being from July, 1924, to July, 1928, so as to enable the units last built to enter the Service at the latest in 1931. Our contemporary hopes that the French Parliament will pass the Bill thus amended, which covers the minimum requirements. The Navy could then await without any too great apprehension the end of the truce decreed by the Treaty of Washington. The contracting Powers regain their liberty of action in the same year, 1931, and no one can foresee what will be at that date the result of evolution in the construction of large naval units.

INTERNATIONAL FOUNDRY TRADES EXHIBITION.—An exhibition is to be held in the Bingley Hall, Birmingham, from June 19 to 28, of plant and materials used in the foundry. The Right Hon. Lord Weir, P.C., has consented to act as President, and practically all the associations connected with the industry have promised their support. The arrangements are well in hand and many of the leading firms have already applied for space. The General Manager is Mr. C. Stanley, of 95, New-street, Birmingham, from whom particulars can be obtained.

THE ACTION OF FROST ON CIMENT FONDU.

DURING the winter some tests have been carried out on the effect of cold and frost on the setting and hardening of Ciment Fondu. Similar work has been carried out on the Continent. It is found that an elevation of temperature from the normal, which is taken as 64 deg. F., up to 86 deg. F., tends to retard the actual setting time of Ciment Fondu, while a reduction from the normal to any temperature down to 32 deg. F. does not appear to have any influence on this characteristic. As regards hardening, cubes made at normal temperature and maintained thereat for 24 hours, and subsequently at a temperature of 32 deg. F., show results at different ages equal to those kept throughout at normal temperature. On the other hand, cubes mixed in the open air at 32 deg. F. and subsequently immersed in water at 32 deg. F. for 24 hours, show a very slight loss compared with the resistance of samples made and kept under normal conditions. The amount is so small, as a matter of fact, as scarcely to exceed the possible range between samples, but is apparently sufficiently consistent to suggest a slight drop.

As we have previously recorded, the setting of Ciment Fondu is accompanied by the early production of a considerable amount of heat. This is an advantage in its use for concrete in cold weather, since, if the concrete is mixed and can be maintained for the first four or five hours at a temperature above 32 deg. F., hardening will follow its normal course, as the heat produced will counteract the effect of a fall of external temperature. If, on the other hand, the cold is so severe that the concrete cannot be kept at a temperature above 32 deg. F. while the initial set takes place setting will be retarded. It may, however, be pointed out that a mass of concrete is not a good conductor and that the fall of temperature of this material in bulk only proceeds very slowly unless the conditions are exceptionally severe. Thus normally the internal generation of heat will supervene before the mass has been reduced to freezing temperature. Under very severe conditions this, of course, may be ensured by the use of hot water for mixing. This contrasts with Portland cement concrete in which the time taken in hardening is so long that freezing may occur before stable conditions have been reached, and the delay in the generation of internal heat makes this of little assistance in these circumstances. Tests with Portland cement concrete go to show that the highest temperature is reached in from three to six days instead of as with Ciment Fondu in a few hours. The effect of low atmospheric temperatures would naturally therefore be greater on Portland cement work.

Experiments have further been made on the use of chemicals such as calcium chloride or salt, to lower the freezing point of the mixture, as is done with Portland cement. Such agents are not recommended for Ciment Fondu, the setting of which is retarded to such an extent that in the early days the strength is very low.

For cold weather work the rapid internal generation of heat in Ciment Fondu certainly appears to be a valuable feature, lacking in the ordinary cements, with which, as is well known, all sorts of methods are adopted to permit of the work continuing through the cold part of the year. In many countries a great deal of concrete work is done under severe cold, and elaborate methods have been devised to meet all manner of enterprises. Contractors and others, we should think, would welcome any satisfactory means of meeting the difficulties thus presented. From the foregoing it would appear that the new cement has great possibilities in this direction.

TRAINING IN MINE RESCUE WORK IN THE UNITED STATES.—Practically 100,000 miners have been trained by the Bureau of Mines in mine-rescue and first-aid methods since the establishment of the bureau in 1910, according to the Annual Report to the Secretary of the Interior for the fiscal year 1922–23. Whereas in 1910 the Bureau trained 734 men, during the past year 14,941 men received the training, which was conducted in 35 States and in Alaska. Although it can now be said positively that widespread explosions of coal dust no longer should occur, the fact remains that they continue. In 1922 gas and coal-dust explosions in the United States took a toll of 311 lives, or 15·78 per cent. of the total deaths. Until the late series of disastrous explosions, the lessening number of explosions in recent years had led the Bureau to feel that the dangers from this source were being eliminated. The two most effective methods for preventing the spreading through a coal mine of a minor initial explosion have been convincingly demonstrated by the bureau at its experimental mine near Pittsburgh, where more than 500 experimental explosions have been produced and in which the explosibility of coal dusts from all parts of the country has been studied. The methods adopted in these demonstrations are the thorough wetting of the dust or the dilution of the coal dust with shale dust, limestone dust, or other non-inflammable dust so that flame will not pass from point to point. This method, we may remark, was first shown to be effective in England.

* See W. F. Durand, *Mechanical Engineering*, October, 1921, page 643.

IGNITION EQUIPMENT FOR A 7,500-H.P. GAS ENGINE.

CONSTRUCTED BY MESSRS. LODGE BROTHERS AND CO., ENGINEERS, RUGBY.

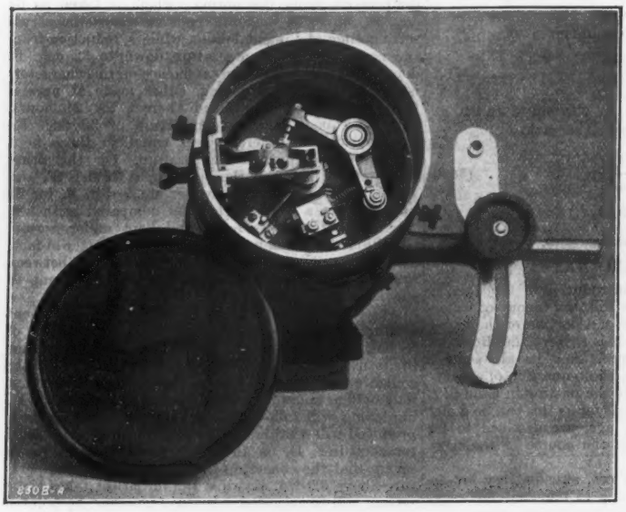


FIG. 1. CONTACT MAKER.

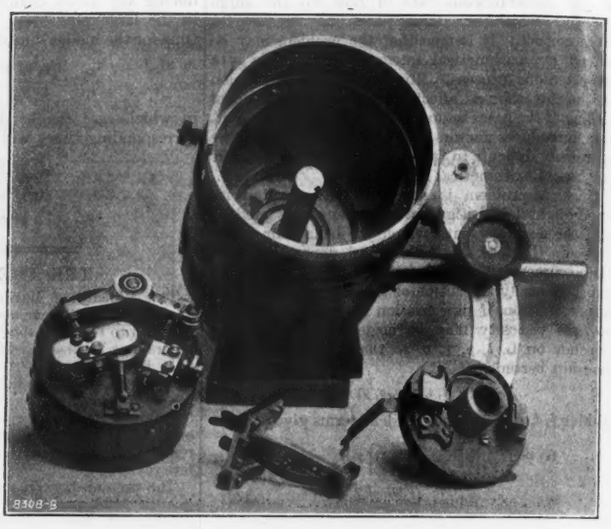


FIG. 2. CONTACT MAKER DISASSEMBLED.

VERY large gas engines, particularly those running on blast furnace gas of low calorific value and containing much moisture, require ignition apparatus capable of furnishing at the gaps of the sparking plugs a much greater amount of electrical energy than suffices for the ordinary motor car or small gas engine. The choice of ignition apparatus for such engines lies between the low-tension system, in which an arc occurs between moving points in the cylinder, the ordinary high-tension ignition in which the spark is supplied by a large slow-running magneto or induction coil, and the Lodge high frequency system. Of these the last is without doubt the most expensive, but in the case of big engines first cost is of minor importance compared to absolute reliability of running. In the Lodge system, the benefit of great accuracy of ignition timing is obtained just as with the ordinary high-tension system, but in addition the high frequency spark is less affected by moisture than either the high-tension or the low-tension ignition system. It is chiefly for its ability to ignite regularly despite dirt or moisture that the Lodge system of ignition is fitted to so many large gas engines all over Europe.

In the accompanying figures we illustrate a set of equipment recently supplied by Messrs. Lodge Brothers and Co., of Rugby, for a 7,500 h.p. gas engine building by the Société Anonyme John Cockerill, of Seraing, Belgium. Of the horizontal type, the engine has two lines of double-acting tandem cylinders. In each of the eight combustion chambers there are fitted two sparking plugs, simultaneously fired in series by a Lodge igniter, of which, of course, eight are required for the whole engine. Mounted on the end of each camshaft is a timing unit consisting of a cylindrical casing containing a contact-maker with a condenser and a low-tension current distributor, through which the igniters are put in circuit in turn.

The contact-maker is shown in Fig. 1, while in Fig. 2 the same unit is shown dismantled, the rotor in an inverted position being on the right of the figure. One of the Lodge igniters with the inspection covers open to expose the trembler and spark gap, together with one timing unit and a sparking plug and its cable terminal are shown in Fig. 3. The barrel of the timing unit is approximately 7 in. diameter by 9 in. long, the flanged driving coupling being 5½ in. diameter and the height of the igniter box 18 in. when the lids are closed. The construction of the Lodge igniters does not vary from what has been previously described. Briefly, they consist of a very large induction coil which charges up a high-tension condenser consisting of two Leyden jars. These igniters produce a white-hot spark of great power. The contact-makers, although not new in principle, have a number of new details which are the outcome of considerable experience in designing ignition gear for large gas engines.

Attached to the camshaft by the flange seen in Fig. 3 is a short stiff shaft, upon which two ball journal bearings are mounted, the aluminium body of the timing unit riding on the outer races. The end of the shaft, which has a long keyway, can be seen with one of the bearings in Fig. 2. Limited angular movement of the timing unit casing is permitted by a slotted quadrant, of which one end is attached to the engine, a clamping device being provided to enable the setting to be locked at any point over a range of 40 deg., the exact timing being indicated by a pointer working over an engraved scale on the quadrant. In order that the pointer may come to zero on the scale at any desired crank angle, the hand lever is frictionally gripped on a boss on the casing, so that by slacking off the clamping bolt the parts may be brought into the correct angular relationship and then locked by the clamp.

Slipped over the shaft and driven by dowel pegs engaging in the keyway therein is the distributor rotor, of which the inner face is shown on the right of Fig. 2. Two rectangular copper-carbon brushes are pressed outward by bow springs and run on a track formed by the segments within the body, one complete segment and parts of two others being visible in the figure. The distributor segments are, of course, insulated from the body and machined to a smooth cylindrical track; they are in communication respectively with the four terminals of which two can be seen in Fig. 3. It should be noted that in the distribution of the current the copper-carbon brushes always rub on a metal surface as the insulating strips between the segments are narrower than the brushes. Also, no sparking occurs on the distribution ring because the

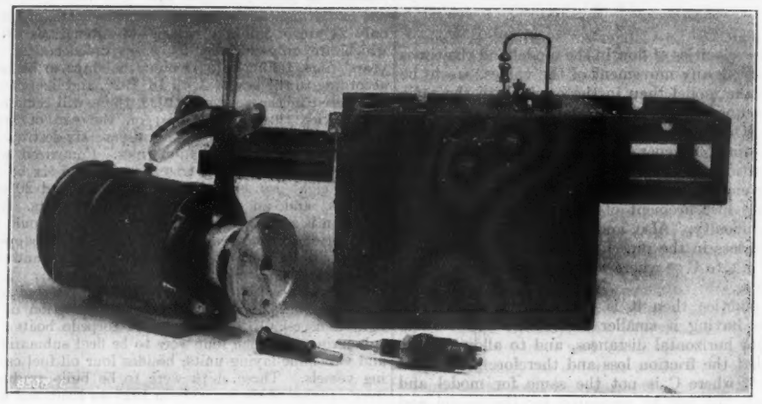
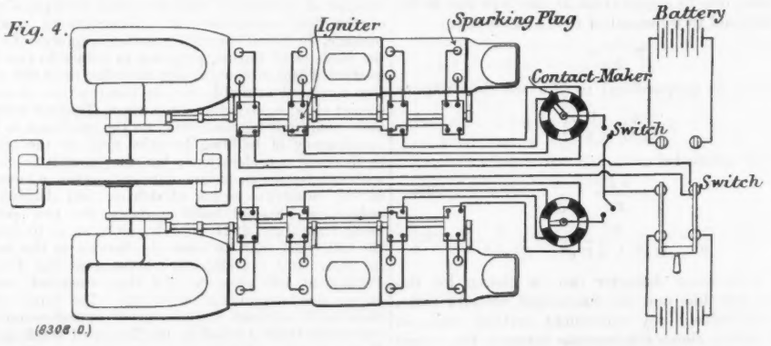


FIG. 3. IGNITER, TIMING UNIT AND SPARKING PLUG.



interrupting of the circuit occurs between the platinum points of the make-and-break. Current is conducted to the distributor brushes by way of a brass strip which engages with a bolt on a brass block carrying the contact-maker spring adjusting screw. This small bolt is the only part requiring any tool for the removal of the interior parts of the timing unit.

Designed on the same general principle as that of an ordinary magneto make-and-break device, the contact-maker is an exceedingly robust piece of work, the aluminium lever being pivotted on ball bearings and provided with ball bearings as rollers to ride upon the cams. As the Lodge igniters are fitted with tremblers the contact-maker is called upon only to time the ignition and control the period during which the tremblers are in operation, a succession of sparks commencing at the plug points when the contacts close and ceasing when these open again. In the position shown in Fig. 1 the contacts are about to close, the rotation being anti-clockwise as thus viewed. In the case of large multi-cylinder engines, especially of the double-acting type, partly owing to the obliquity of the connecting rod and partly to differences in the inlet parts, the best position for the ignition of each cylinder-end has to be found by taking indicator diagrams. Once this position has been settled, the timing does not vary. To allow for this exact timing, the individual cams, which actuate the rocking lever, may be moved over a range of a few degrees. The cams, which are made of hard vulcanised fibre, are fitted into a groove turned in the outside casing. Each cam is secured by a pair of studs with knurled nuts, an engraved scale being provided on the outside to facilitate their setting, which can be effected while the engine is running.

Built up on a bronze centre having dowel pegs entering the keyway in the shaft, the contact-maker base is of fibre, and carries the steel pivot pin for the lever, together with the "stationary" contact and the spring abutment. A locking bolt engages in a hole in the shaft and secures the complete contact-maker, and thereby the distributor rotor, in position. Behind the contact-maker is a large circular low-tension condenser, the connections being made by short lengths of insulated flexible copper wire. Normally this condenser is inoperative, as each igniter is provided with its own condenser; but should the main timing contacts open at an instant when a trembler is closed and therefore current passing, the auxiliary condenser will prevent a spark from taking place at the contact points. Under such circumstances the life of the main contacts, which are extremely heavy and of iridio-platinum alloy, should be indefinitely long.

From the battery, current passes to the "stationary" contact screw by way of a brush sliding in a holder carried in the extremity of a pedestal bracket, which is insulated from the body and fixed in position by a single bolt with a butterfly nut. This bracket is visible in the foreground of Fig. 2, and can be seen in position in Fig. 1. A light cover of spun aluminium, frictionally held in place by three ball-ended spring backed plungers, permits of inspection of the contact-maker while the engine is running.

The Lodge igniter for each combustion chamber is mounted on the engine quite near the two sparking plugs that it serves, so that the length of the high-tension circuit is kept as short as possible. This is an important point when dealing with high frequency currents. The low-tension connections between the battery, the contact-maker and igniters are carried out by using ordinary electric light wire, and the complete circuit is arranged so that there is no "earth." The diagram of connections is shown in Fig. 4. Each igniter fires two sparking plugs in series; by this means two igniting points are obtained on opposite sides of the combustion chamber, absolutely simultaneously, thereby reducing the time of flame propagation.

The Lodge gas engine plug has an oxidised steel body screwed to 1-in. Whitworth gas thread, the insulation being of mica, and four spark gaps surrounding the head of the central electrode. The complete insulator may be removed for cleaning by unscrewing a hexagon gland nut. Insulated handles are provided, by means of which the cables may be disconnected from any plug at will, and with the current "on" if necessary. Two five-cell batteries of accumulators of nominally 10 volts each are to be used, switches being arranged so that the ignition system may be run from either battery while its fellow is being charged. Other switches permit of each side of the engine being cut out independently, while on each igniter there is a reversing switch to change the direction of the primary current across the trembler contacts. Daily reversal of these switches serves to prevent uneven wear of the trembler contacts.

LONDON ASSOCIATION OF FOREMEN ENGINEERS.—The 71st anniversary festival of this Association will be held at Cannon-street Hotel at 6.20 p.m. on Saturday, May 3.

JOIST AND GIRDER BRACKET CLIP.

THE accompanying illustrations, Figs. 1 to 3, show a convenient little standard clamp which is put on the market by Messrs. Buck and Hickman, Limited, Whitechapel-road, London, E., for fixing brackets for line shafting, countershafts, &c., to structural members of T or I section. The illustrations are self-explanatory, each clamp consisting, as will be seen, of a block to the centre of which the bracket is bolted, while at either end is a clip which overlaps the flange of the structural member. The clipping piece is fitted with a rocking edge which drops into a groove on the block, and the

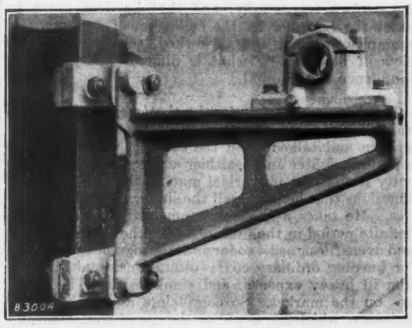


FIG. 1.

FIG. 2.

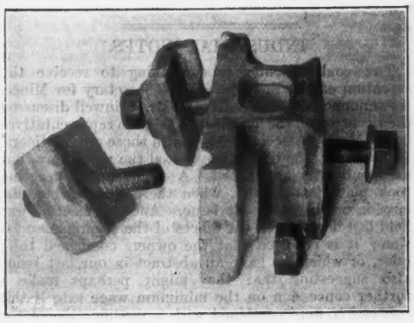


FIG. 3.

necessary grip is secured by bolts passing through both pieces. From its construction it will be clear that the clamp can be very quickly fixed, and that with it standard brackets can be used on any sized beam or stanchion. Any reasonable thickness of flange of the column or joist can be taken care of by this clipping system, while Fig. 2 will indicate that one size of clamp is serviceable for a considerable range of girder-flange width. The clamp is adaptable to all positions, while no damage is done by drilling to the structure, so that temporary fixtures or alterations of arrangement can be adopted without hesitation. The clips, we understand, are made in four sizes to meet the requirements of light and heavy work, though, as we have pointed out, each size allows a very considerable degree of latitude.

AMERICAN IRON AND STEEL PRODUCTION.—The United States production of pig iron in February amounted to 3,074,757 tons; the daily average was 106,026 tons. The steel ingot production was 3,780,663 tons, and the daily average 151,227 tons.

NOTES ON NEW BOOKS.

A BELIEF is prevalent, and not infrequently expressed, that advances in science, betraying as they do a keener and more accurate view of the mechanism of nature, are not an unmixed blessing to the community. Necessarily, accumulated knowledge can be used for good or evil, development cannot be confined in one direction. The boldness of imagination that makes scientific achievement possible cannot be limited by fear of consequences, or stayed by the possible prostitution of its gifts. At times a genuine fear gains ground that the world needs protection against the destructive forces of science, that arm man to work physical ruin without increasing his moral and ethical qualities. The timid dread that science will wreck civilisation is as widespread as the generous appreciation of its material benefits. It is difficult to argue with those who persist in indulging in one-sided opinions, who insist in seeing in an aeroplane simply an instrument designed for destruction, and will not consider its value as a machine for transport or a contributor to the means of locomotion. But to those who hold such limited and distorted views a catalogue of some of the benefits accruing from the labours of scientific workers may prove reassuring and corrective, especially if it induces the timorous pessimist to take a wider survey than that contemplated by Messrs. Pilcher and Butler-Jones in the second edition of their little work, "*What Industry Owes to Chemical Science*" (London: Constable and Co., Limited; Price 6*s.* net.) The authors limit their contribution to considering the manner in which chemistry has facilitated manufacture and promoted industry, and though the rewards are seen to be rich beyond calculation, they necessarily form but a small fraction of the total achievements in science. In medicine, in biology, in agriculture, in physics, in whatever direction we may look, the culture of pure science has been to make life fuller, to accomplish more for less exertion, to provide man with more efficient weapons for securing his comfort and well-being. And as Sir George Beilby points out, in a brief but stimulating introduction, the harvest is not yet fully gathered. More and more fully trained experts will be required to carry on the highly organised industries of the future, and greater opportunities for research will be provided. With a greater army of workers demands will be more intense and improvements may be expected to accumulate in a geometric ratio. The plan adopted by the authors to remind us of the benefits derived from the application of pure and experimental science is to take each industry in turn and show by examples how chemical science has improved the processes of production, or devised entirely new methods of economical working. Metallurgy, leather, rubber, refractory materials, photography, brewing, and a host of other industries are passed in review, but as this is a second edition there is less necessity to dwell upon any of the details. Solid progress rather than sensational development has guided the authors in their selection, and in some cases as much more could be added as is given, but this restraint only serves to show the wealth of material at disposal. The central object was not to present a pleasant and finished literary work, which would stimulate the imagination of the general reader, but to set forth in their bare simplicity the broad facts of achievement, leaving each case to make its own appeal.

Pistons are important parts of engines, and their design and construction may possibly justify a special treatise. The number of such monographs is certainly small, however, and the book on pistons which C. Volk edited in 1911 as first volume of his collection of "Einzelkonstruktionen aus dem Maschinenbau" was probably a novelty. The second edition of this book, "*Kolben*, I. *Dampfmaschinen-und Gebläsekolben*, II. *Gasmaschinen-und Pumpenkolben*" [Berlin: Julius Springer; price 0·90 dol.), compiled by C. Volk, Lecturer at the Technische Hochschule, Berlin, and A. Eckhardt, of the Gasmotorenfabrik Deutz, has to outline developments, but hardly to describe any essentially novel types, because the pistons for the engines of automobiles and aircraft are left to a special treatise. The 77 pages of the book, which is very well illustrated by 252 figures, deal with pistons for steam engines and blowing engines and with pistons for gas engines and pumps. The book does not contain any historical sections; there are very few literature references, but the manufacturers of the pistons described are named. That German firms strongly predominate is not surprising. We notice that the slippers for heavy two-part pistons, sometimes used in uniflow engines in order to reduce the load on the cylinder bottom, have also been adapted to two-cycle gas engines.

Every year more and more complicated calculations are demanded from those responsible for proportioning structural steel work. Whether the tendency is due

to a practical need, or whether it only originates in a not unnatural desire of the computer to magnify his office, may be a matter of dispute. Whatever the reason there is to-day a demand that secondary stresses shall be computed, and that deflections shall be calculated by exact instead of by roughly approximate methods. Even those who fail to see any basis for these requirements in the reports of maintenance engineers will agree that computers ought to be able to make the calculations in question, even if they deem the exercise to be in most cases of no practical significance. The needs of the modern stress computer are excellently met in the treatise on "*Stresses in Framed Structures*," published by the McGraw-Hill Publishing Co., Limited, London at 25*s.* net. The book forms one of a series of six volumes on structural engineering compiled by a staff of specialists, with Professor G. A. Hool and Professor W. S. Kinne as editors-in-chief. The calculation of stresses has long been very thoroughly systematised in American bridge works, and this condition is reflected in the present volume, which gives not merely the general theory but also explains in detail the methods of computations which have proved most convenient in practice. In the more advanced portion of the volume we have a full explanation of the ingenious Williot diagram as applied to the determination of deflections. There are also very complete sections on redundant frames and secondary stresses. No use is made of Castigliano's theorem, which seems to us to provide the simplest and most readily comprehensible method of attacking these problems. Of course, the same final equations are reached, whatever method be used. Apparently the term secondary stresses is in this volume confined to those arising from redundancy at joints. The character of the deformations due to these are very clearly shown by a number of excellent diagrams. The treatise covers very completely the whole problem of the determination of stresses in framed structures. There are a number of valuable tables, and the text is illustrated by some hundreds of well selected diagrams.

IN 1879, Mr. E. H. Hall found that when a current was passed through a strip of gold leaf, which at the same time was subject to a magnetic field perpendicular to the plane of the strip, the equipotential lines corresponding to the normal flow of the current were displaced, and further investigation established the interesting fact that these distorted equipotential lines were no longer perpendicular to the stream lines of the current. This discovery was rated by Lord Kelvin as comparable with the greatest made by Faraday, and it may be noted that it confirmed certain conclusions he had advanced as probable nearly 30 years before. Much has been added since 1879 to the work of Hall, a number of associated phenomena having been demonstrated by different workers. The theory is, however, still far from satisfactory, a condition which perhaps is to be considered less of a disability than as a promise that further research may lead to conclusions of fundamental importance on interatomic action. A very complete synopsis of what has so far been established is provided by Professor L. L. Campbell's "*Galvanometric and Thermomagnetic Effects*," which has just been published by Messrs. Longmans Green and Co. The volume forms one of the series of Monographs on Physics, which the firm are now issuing under the editorship of Sir J. J. Thomson and Dr. Frank Horton.

In producing a second edition of a mathematical text-book after an interval of ten years, most authors find that an entirely new setting is necessitated by the altered conditions of teaching. The problems and facts remain the same, the fundamental principles to be acquired do not change, but emphasis varies and perhaps novel methods of treatment are required to meet the demands of examiners and the scope of technical literature. Mr. Ernest H. Sprague finds himself no exception to the rule, and in offering a new edition of his "*Hydraulics*" (London: Scott, Greenwood and Son; price 8*s.* 6*d.* net) he states that his work has been re-written. He does not attempt to accommodate his work to the examination syllabus of any authority, but outlines his subject with thoroughness and freedom that are the more welcome for being unusual. There is no reason to apologise for the use of the calculus in examples in which it is necessary or convenient to employ such devices. The fact that the student is attacking this subject should imply that he has been placed by previous instruction in possession of the tools that will enable him to force a road through the obstacles that beset his progress. The range of subjects discussed is necessarily somewhat restricted, since it must necessarily be limited to the consideration of the behaviour of water in the various conditions under which it is placed. The mechanical applications are, of course, unlimited, but here attention is directed to only a few typical instances. Bernouilli's theorem and its deductions cover much of the purely mathematical or theoretical side, and practically water can flow only through orifices, or over weirs, through pipes and along open channels. Brought into contact with appropriate machinery, water may be used in distinct ways, in motors, in turbines, in pumps, where power has to be determined, efficiency measured, losses estimated and reduced, by methods that tax to the utmost the ingenuity of the hydraulic engineer. With the details of this machinery we have little to do. We have to ask ourselves, does this treatise furnish an adequate introduction to the student who would understand the difficulties and problems that the science of hydraulics presents. We think the author has treated the subject successfully, and that he does much to assist the beginner by the collection of a number of examples, worked and unworked, selected with the view of illuminating what is difficult and of giving confidence to the pupil.

If the measures taken for the abatement of the smoke nuisance were at all commensurate to the amount written and talked upon the subject, we might have a purer, brighter and healthier atmosphere. The difficulty is that the proverbial man in the street, even if conscious that he is himself the sinner, is pretty powerless. He takes a house or room, probably for an indefinite period in the first instance; he finds fireplaces and ovens, designed—so far as design can be spoken of—for burning ordinary coal; alterations would involve him in heavy expense, and smokeless fuel is hardly yet on the market. So complaints about the smoke nuisance, which are as old as the use of coal, continue. we want smoke inspectors to check the evil, and so follows the publication of "*The Smoke Inspector's Handbook*," by Mr. Herbert G. Clinch (H. R. Lewis and Company, 28, Gower Place, W.C.1; price, 7*s.* 6*d.*), possibly the first of its kind. We wish, however, that the aim of Mr. Clinch, who is chief smoke inspector of Halifax, Yorks, had been less markedly "to assist sanitary inspectors and public health officials to a proper understanding of the sequence of events in the furnace," and that he had more strictly kept to his subject. Whole pages of illustrations of well-known types of boilers are too prominent in this volume of only 136 pages, and illustrations of water softeners, and the remarks on the advantages of economisers and on boiler scale are out of place. The list of CO_2 apparatus is defective, on the other hand. The chapter on smoke is limited to six pages, and the smoke and dust researches and apparatus of the Meteorological Office and Dr. Owens are not even referred to. Moreover, Mr. Clinch seems to side with Mr. Cyril Banks, Medical Officer of Halifax, who, in the preface to the volume, regrets the tendency of reformers to talk more of domestic smoke than of factory smoke.

INDUSTRIAL NOTES.

THE coal difficulty is continuing to receive the attention of Mr. E. Shinwell, the Secretary for Mines. As announced in our last issue, Mr. Shinwell discussed the situation on the 20th inst. both with representatives of the Mining Association and with those of the Miners' Federation; the discussions lasted the whole day, but no result was announced. A similar joint meeting took place last Friday, when there was further discussion on the points at issue. Another meeting was held last Tuesday at the offices of the Mining Association; it is reported that the owners confirmed their offer, of which we gave an abstract in our last issue, also suggesting that they might perhaps make a further concession on the minimum wage rate if this concession were combined with a modification of the terms governing the ratio of wages to profits. These conditions were gone into on Wednesday, at a meeting of the men's delegates, held in the Memorial Hall, Farringdon-street, when it was decided to seek a further conference with the owners. This conference was proceeding at the time of our going to press.

Following upon a demand by the London tramwaymen for an increase in wages of 8*s.* per week, a demand which the employers stated the various Metropolitan tramway undertakings were unable to meet, the tramwaymen went out on strike at midnight last Friday. The London 'busmen struck at the same time, in sympathy. Previous to the strike the employers expressed their willingness to submit the demand to an independent arbitrator, the Transport and General Workers' Union, to which the men belong, however, declined. Sir D. Shackleton, of the Ministry of Labour, thereupon intimated that the Ministry had decided to set up a Court of Inquiry under the Industrial Courts Act, and asked whether the notices to cease work could be held over. A meeting of the union leaders then took place, when the strike was decided upon. Since then interviews have been held between the union and Mr. Tom Shaw, Minister of Labour. The Court of Inquiry was, nevertheless, appointed by the Minister of Labour; it consists of Sir Arthur Colefax, K.C., chairman; Mr. G. W. Paton, as representative of the employers; and Mr. Arthur Pugh, secretary of the Iron and Steel Trades Federation. The Court of Inquiry immediately sat for the purpose of taking evidence. The main point brought out was to the effect that unified control of all the transport facilities—railways, omnibuses and tramways—was the only way of dealing with the situation, namely, the wages problem, and also the present traffic chaos in London. Before the tramwaymen actually went on strike the London County Council offered 5*s.* per week increase in the wages of motormen, conductors, regulators and inspectors (the "uniform" men), an offer which would involve an increased expenditure of about 100,000*l.* per year.

The following are the terms of the interim report presented by the Court of Inquiry to the Ministry of Labour:—

"On the statements and evidence submitted to the Court we have reached the following conclusions, which we feel should be placed before you forthwith:—

"(*a*) Throughout the inquiry the merits of the claim on behalf of the workers for an increase of wages were not seriously questioned.

"(*b*) The present crisis has, in the main, arisen through the tramway undertakings in the Metropolitan area being unable to earn sufficient to meet the claim. This has been brought about by the severe competition of the omnibuses in the absence of any co-ordinating control, by the heavy expenditure on renewals and upkeep of the permanent way at present high costs, and by the discharge of the statutory obligations for the maintenance of the surface of the highway.

"(*c*) There is unanimity on the part of those who have appeared before us competent to express an opinion on the matter that the solution for the present unsatisfactory position of the industry in the Metropolitan area is not to be found in an increase of fares.

"(*d*) All parties express the view, with which we concur, that without some co-ordinating control of passenger traffic within the Metropolitan area there is little, if any, prospect of improvement in the condition of the industry.

"(*e*) A definite undertaking by the Government to introduce and press forward legislation placing the passenger traffic of the Metropolitan area under some co-ordinating control, affords, in our view, a basis and the only one at present suggested, for re-opening negotiations between the parties.

"We have indicated very briefly the course of the inquiry, and the conclusions we have so far reached, and shall examine more closely the detailed evidence before submitting our final report."

A meeting of representatives of the Metropolitan traffic undertakings with representatives of the Transport and General Workers' Union, took place at the Ministry of Labour last Tuesday. The employers offered an immediate advance of 5*s.* per week to the motormen, conductors, inspectors and traffic regulators, and they agreed to arbitrate as regards the balance of the claim of 8*s.* per week and the claims so far as it affects the other grades of tramway employees. This offer was rejected by Mr. Bevin, on behalf of the union. On Tuesday also a "London Traffic" Bill was introduced in Parliament by Mr. Gosling, the Minister of Transport. Its object is "to make further provision for the control and regulation of traffic in and near London, and for purposes connected therewith."

At the time of writing it is announced that the leaders of the Associated Society of Locomotive Engineers and Firemen have decided to send out notices to the members working on the Tubes and on the Underground Railway ordering them to cease work as from to-day at midnight, unless in the meantime the men are otherwise instructed. The representatives of the National Union of Railwaymen met yesterday afternoon to consider the situation.

The precarious situation of the British iron and steel trades is shown in a statement issued by the National Federation of Iron and Steel Manufacturers. According to this only 190 blast furnaces are in operation to-day, compared with 303 in operation in September, 1920, and the number is still decreasing. The statement adds:—

"Continental competition—favoured by falling exchanges, a lower standard of living, and longer working hours—renders it under existing conditions almost impossible for the iron and steel industry to maintain even the level of production recently attained, so that any condition tending to a still further increase in the cost of production must react to the disadvantage of the industry, by reducing the volume of production possible. As approximately 4 tons of coal are required to produce 1 ton of finished steel, it is obvious that any increase in the cost of fuel will be reflected fourfold in the cost of the finished steel product. On the basis of production of 1923, which was only

two-thirds of normal capacity, an increase of, say, 3*s.* per ton in the cost of coal would be an additional burden on the iron and steel industry of 4,500,000*l.* per annum, and 12*s.* would be added to the cost of every ton of finished steel."

"The prospects of a coal strike or even, if that is averted, an increase in the cost of fuel, is having a disheartening effect upon both producers and users of pig-iron," says the secretary of the London Iron and Steel Exchange, Limited.

It is announced that the Barrow Steel Company have decided to close down their works owing to trade depression occasioned by trade disputes; following this decision a thousand men will be thrown out of work.

Repeated meetings which have been held during the last few days failed to bring about a settlement of the difficulty. On Wednesday, the negotiating committee of the Shipbuilding Employers' Federation, together with the Southampton Employers, met in conference representatives of the Federation of Engineering and Shipbuilding Trades, of the Shipwrights' Society and of the Amalgamated Engineering Union. The employers' representatives failed to induce the representatives of the Southampton men to recommend a resumption of work prior to negotiations. After both sides had considered the situation, the employers' representatives issued the following, as their considered policy, to the representatives of the Federation of Trades, the Shipwrights' Society and the Amalgamated Engineering Union :—

"When we met in Carlisle last week we intimated that we felt ourselves compelled to support our Southampton members. In view of the fact, however, that as responsible executive representatives you admitted that the strike was unofficial and irregular, and you were prepared to make another effort to effect a resumption of work, we agreed to the suggestion for a composite conference, and we accordingly deferred taking any action until such conference had been held. We regret that the continued persistence of the Southampton men, as revealed in the composite conference to-day, leaves us no alternative but to intimate that on and after a certain date employment will not be available in federated ship establishments to members of those unions whose Southampton members have not returned to work on a date before then. The dates we had decided upon were Thursday, April 10, and Tuesday, April 8, respectively. But in view of the urgent representations made to us to-day to give the executives one more opportunity to deal with the Southampton situation before officially intimating the date of the lock-out, we agree to adjourn this conference until Tuesday, April 1. In the meantime the offer which we made at Carlisle for dealing with the Southampton claim remains open. If as executives you feel you would prefer that the second part of the claim should, immediately work is resumed, go straight to the Industrial Court for determination, we are prepared to agree."

"PRODUCTION COSTS IN THE ENGINEERING INDUSTRY."

TO THE EDITOR OF ENGINEERING.

SIR,—Your article on February 29, regarding production costs, was extremely interesting and timely, and with your consent I should like to fill in one or two thoughts in connection with same which you have not touched upon.

Taxation.—Very few people appreciate how taxation adds to production costs. It is not so generally known as it ought to be that the taxation on every ton of steel in pre-war days was, in 1913, 2*s.* 9*d.* against 21*s.* 4*d.* to-day. The effect of this is also seen in wages. Every married man to-day pays approximately in direct and indirect taxation, 5*s.* per week, twice as much per head as the people in France.

Freights.—As a result very largely of taxation superimposed on high wages and actual costs, these charges are now an onerous burden, in some cases amounting to as much as 20*l.* for every 100*l.* of productive wages in actual manufacturing. Economies in this direction can be made if full use is made of road transport, and greater co-operation ought to exist in seeking for return loads throughout the country for all motor lorries and a keen live despatch clerk, keeping in touch with carriers, can soon more than earn his salary.

Materials.—If these have reached rock bottom they are still extremely high. Especially is this the case with cast iron. Mild steel and sheet steel are still much higher than they ought to be and efforts should be made to bring our material prices down to, at least, 30 per cent. above pre-war prices. This country, depending, as it largely does, on cheap coal and iron, must use every effort to see that prices are brought back nearer the old figure.

Wages.—Whilst wages are a serious item, too much stress is laid on the question of further reduction. If works would only study thoroughly the question of increasing cutting times on tools, wages would cease to be such a large proportion as they are at present. Cutting times, as shown by Mr. Baillie's paper which was read before the engineers twelve months ago, brought this point out very clearly and, from observations which I have made from time to time, I think it is quite likely that in the average engineering shop in the country actual cutting times will not amount to 25 per cent. of the whole. Very few people will be prepared to agree with this, but if cutting times are carefully calculated against actual times, investigators will find this figure to be correct. All those making time studies know full well the tremendous amount of time lost by shortage of material, incorrect drawings, drawings with too little detail, and when it comes to assembly it is surprising to find errors in measurement and gauging made by some of the leading firms in the country.

The last paragraph of your article struck the writer as being of extreme interest. Great economies can be effected by keeping up-to-date in the use of new materials. The writer has recently seen how large economies can be effected in certain cases by the use of cast steel where the quantities were too small for drop forgings. High tensile steel can also be used in the same direction. Large advances are being made in the use of aluminium bronze with which all engineers ought to keep themselves in touch. Die castings can now be made with a melting point of 1,200 deg. C. The following instance shows how twelve months makes a big step forward :—Just over a year ago a decision had to be made regarding the use of two materials which we will call "X" and "Y." After a great deal of consideration "Y" was chosen on the ground of economy although "X" was recognised as being superior. The matter was looked into again this month and it was found that "X" can be purchased to-day at 25 per cent. below the price of "Y." A large saving has consequently been effected and a superior metal supplied.

Too few people recognise that costs of production can be brought nearer pre-war limits than they are at present if this goal is constantly kept in front of them. The secret of all cost productions, however, lies in constant repetition work and engineers all over this country will persist in forsaking the standard line and making special articles. Cost production can never be made along these lines and standardisation will have to be insisted upon more and more if engineering firms hope to weather the present period of depression. In this connection, sales engineers can render immense service in pushing their firm's standard article, especially if they conscientiously believe it to be the most superior of its kind on the market.

Yours faithfully,
ARTHUR S. MURDOCH, Works Manager,
The British Electric Plant Company, Limited.
Alloa, Scotland, March 19.

TO THE EDITOR OF ENGINEERING.

SIR,—As one who has had many years' experience in costing, I should like to endorse the opinions of your correspondent, Mr. G. H. Nelson, in his remarks on "Costing and Ratefixing," in your issue of the 7th inst. At the present time these are of the utmost importance to engineering firms, and yet, in most cases these two departments are in anything but an efficient state.

Leaving out ratefixing for the time being, and confining myself to costing, I think that inefficiency can be traced to several causes, not the least of which is the personnel. In many cases the department is composed of ordinary office clerks, and frequently women, who have no technical knowledge of engineering, and are just compilers of figures and nothing more. The result is that costs are seldom up-to-date, and still more seldom correct, though the latter is not always apparent, until losses have been made on contracts, or orders lost. This also undoubtedly accounts for the wide differences shown by different firms in the same line of business in quoting for the same work. Too many employers look upon costing as a clerical job pure and simple, but if costing is to be considered seriously, the man responsible for such costing must be possessed of engineering experience.

It has to be considered that all costs originate in the shops, therefore, any mistakes made, or intentional manipulations are reflected in the cost records themselves, unless the cost department has a thorough knowledge of workshop routine and the methods employed in manufacturing, and can use that knowledge in the detection of such errors.

Again, in the compiling of expense accounts, the most ludicrous mistakes are sometimes made by those who are unaccustomed to materials, &c., and their application to overhead and departmental charges, particular items being charged to one account one month, and to quite a different account the next, according to the interpretation of the works orders and account numbers by different individuals, their value thus destroyed for comparative purposes. Of course, this does not make any difference to the total of *all* the monthly expense accounts, as these balance, or should do.

Another cause of the chaotic state of some cost departments is the attitude of the management towards the expense of the department itself. In pre-war days, when trade was good, costing was often looked upon as an unnecessary luxury, a rough estimate was quite good enough; nowadays, the state of trade doesn't permit of the setting up of better methods, so the rough and ready methods still go on, till better times appear, when serious costing may not be so necessary.

Of costing systems there is no lack, and some of them are quite practicable, but *a paper system alone*, will not in itself improve matters, unless there is an intelligent driving force behind it. I have seen two systems inaugurated by experts, the last one of which was fallen upon by the management and the various cliques, who combined against the common enemy, and rent the system to pieces, after the expert had taken his departure. It is a curious fact that any attempt to introduce new methods into some works is resisted to the utmost, especially if the introducer be a stranger. He needs to be a strong man who would hold his own under these circumstances; often he conciliates his enemies, with the consequence that he is useless so far as the purpose for which he was engaged is concerned. In my opinion if costing is to be of any use, it must be as nearly perfect as it can be got; half-measures are absolutely dangerous. Again, some managers never take the trouble occasionally to investigate some of the costs that are put in front of them; if they did, they might learn a lot that they didn't know before.

If good results are to be obtained, good men must be in charge, and such men expect a decent salary; a cheap man is a dear one in the long run, for example, I quite recently called upon the manager of a small works, with a view to engagement; almost his first words were: "surely, in the whole of London I can find a reliable cost clerk"; he then informed me that he had spent 1,000*l.* on costing during the past year, all to no purpose; but on coming away I was forced to the conclusion that he preferred to lose money on inefficient staff to engaging men that knew their business. But at the present time all men are put up to Dutch auction by employers, and the cheapest wins.

Yours faithfully,
March 24, 1924. "SOUTHWELL."

"FUEL CONSUMPTION OF MOTOR SHIPS."

TO THE EDITOR OF ENGINEERING.

SIR,—In your issue for January 11 you give some details about speed and consumption for motor-ship Conde de Churruca. I have compared the result given with the results of my own motor vessels, and come to the conclusion that the information you give must, somehow, be wrong. You state that the dimensions of motor-ship Conde de Churruca are 370 ft. by 48 ft. 3 in. by 30 ft., and the draft appears to be about 24 ft. 6 in. You further state that the Armstrong-Sulzer Diesel engines are of 2,500 brake horse-power at 100 revolutions, and that the vessel has averaged 10·3 knots on a consumption of 8·5 tons. This must be wrong because, supposing the block coefficient of the vessel is about 0·775, she would require for the speed indicated only about 1,550 brake horse-power, not 2,500 brake horse-power, and the consumption, of course, should then be very much below 8·5 tons. A motor vessel of mine, 378 ft. by 50 ft. by 34 ft. 5 in. to shelter deck, with draft 25 ft. 6 in., having Burmeister and Wain's engines of about 1,650 brake horse-power at 150 revolutions, maintains about the same average speed as you give for the motor-ship Conde de Churruca, and it seems quite impossible that the vessel you mention, which is considerably smaller, should require engines very much larger to obtain the same speed.

Yours faithfully,
A. P. MOLLER.
Copenhagen K., 8, Kongens Nytorv.
March 15, 1924.

[We have submitted Mr. Moller's letter to Sir W. G. Armstrong, Whitworth and Co., of Elswick Works, Newcastle-on-Tyne, the builders of the Conde de Churruca, who supplied us with the information which we published on January 11, and they have replied as follows :—"This vessel is fitted with engines capable of developing a maximum power at sea of 2,500 brake horse-power on full power, and on her official loaded trial attained a mean speed of 11·86 knots. To meet the requirements of the trade in which the vessel is engaged, the maximum speed is not usually required, and the figure given in your issue of January 11 simply represents a mean of the speeds obtained on the various voyages of the vessel during the period named. These speeds varied from 11·97 to 9·47 knots, and the average power developed would naturally not be equal to the maximum for which the engines are designed. It is obvious that the consumption of 8·5 tons does not correspond to a brake horse-power of 2,500; the consumption at full power with these engines would be in the neighbourhood of 11 tons per day."—ED. E.]

THE EX-BRITISH WESTINGHOUSE ASSOCIATION.—The sixth annual re-union dinner of this association took place at the Holborn Restaurant, London, on the 21st inst., Sir Holberry Mensforth, K.C.B., C.B.E., being in the chair. Sir Holberry joined the British Westinghouse Company in 1904 and remained with them until 1920, when he resigned to take up his present position of Director-General of Factories, under the War Office. The dinner, as has been the rule with these functions, was a great success and the opportunity of renewing old friendships and acquaintanceships was much appreciated by all present. The association may be cordially recommended to all old British Westinghouse staff men who do not as yet belong to it.

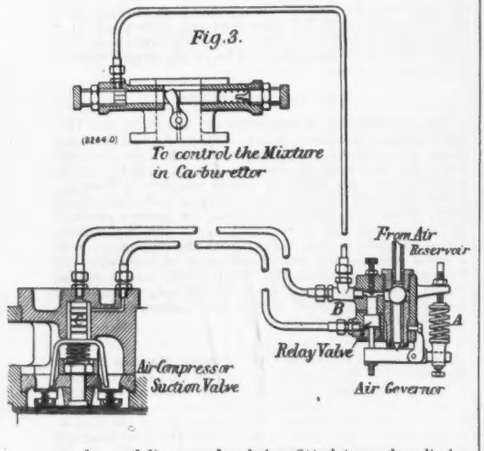
THE FIRST BRITISH DOUBLE-ACTING MARINE DIESEL ENGINE.—Messrs. Barclay, Curle and Co., of Whiteinch, Glasgow, launched last Saturday a single-screw motor cargo vessel, the Swanley, constructed to the order of Messrs. Harris and Dixon. The engines are of the double-acting Diesel type and in fact form the first example of this equipment installed in this country. The North British Diesel Engine Works (1922), Limited, designed and constructed the engines which has three cylinders of 24½ in. diameter and 44 in. stroke, giving 2,000 b.h.p. at 100 r.p.m. Experimental work of an extensive and successful character has been conducted with this engine during a period covering many months. The engine is said to have been run on fuel oil of ordinary boiler quality with great success, because of the advantage of the design in providing a straight through passage for scavenging and the absence of air and exhaust valves.

PORTABLE AIR COMPRESSOR SETS.

THE increased use of pneumatic tools for road and other out-of-door work has led to a number of developments in the past few years in the design of portable compressor sets. Among the recent modifications we show two in Figs. 1 to 8 on this and the opposite pages, which have been introduced by the Globe Pneumatic Engineering Company, Limited, 1, Victoria Street, S.W. The first of these, Fig. 1, is a set on an ordinary portable mounting, but designed for use where a supply of electricity is conveniently available. It is intended for use on structural work and suffices for four Globe Pneumatic drilling machines of 1¼-in. capacity, or six hammers for 1-in. rivets. The set weighs 4,480 lb. The compressor consists of a two-cylinder 8 in. by 8 in. machine running at 340 r.p.m., at which speed the cylinder displacement is 160 cub. ft. per minute. The motor is of 32-h.p. rating, of the A.C. protected type for three-phase 50-cycle supply, and fitted with an oil-immersed drum-type starter. The compressor is driven through internal gearing on its flywheel. The air receiver is 20 in. diameter and 4 ft. 6 in. long.

The remaining illustrations are of a new type of light weight set on a much-improved frame and carriage, specially designed to conform to regulations regarding trailer vehicles, so that it can be quickly taken from place to place behind an ordinary motor lorry or other fast-travelling tractor. The figures actually illustrate a portable set of this type built for the Nigerian State Railways. At present this system is being extended up-country, and this work involves a good deal of rock blasting. The light weight equipment is specially adaptable to quick movement in such a connection owing to being fitted with rubber tyres and well-sprung framing. The machine is also fitted with spring draw gear, and can be effectively braked from the tractor vehicle in conformity with regulations governing the use of trailers.

In this machine for Nigeria the compressor set is a new Globe Pneumatic design of standard pattern, save for the radiators, which are of extra large size especially suitable to the tropics. Normally sheeting covers enclose and protect the whole of the compressing plant; these have been removed in Fig. 2 for the purpose of photographing only. The engine is a four-cylinder 93 × 140 mm. Dorman petrol engine, running at 1,150 r.p.m. and developing 27 brake horse-power; it is equipped with Zenith carburettor, water pump, magneto and forced-feed lubrication. The compressor is a totally enclosed vertical single-acting twin-cylinder machine of 7-in. bore and 7-in. stroke. The cylinders are cast *en bloc*. The compressor runs at 400 r.p.m., at which speed it has a capacity of 125 cub. ft. of free air per minute. The crank-shaft is carried in two ring oiled bearings, kept supplied automatically with oil from the sump in the compressor crank-case. The big-ends are fed independently by means of an oil pump of the injector type, the oil being forced up a pipe running along the connecting rod up to the little-ends. The pistons, of the trunk type, are fitted with three rings and a wiper ring, with a view to reducing oil consumption. The valves are of the low lift pattern of light weight, one inlet and one delivery valve being fitted to each cylinder. Clearance volume has been reduced to 1½ per cent. The cylinder casting is free from complicated passages; the valve pockets are completely water-jacketed, and large hand holes are provided for cleaning.



Governing is arranged both for the compressor and for the engine, this being a special feature of the machine and conducive of course to low fuel consumption. Details of the arrangement are given in Fig. 3. In this the governor is shown to the right, the compressor control in the centre, and the engine control above. The governor is connected with the air reservoir by means of the pipe marked "From Air Reservoir." As soon as the reservoir pressure exceeds the intended amount, the ball valve is depressed against the action of the spring A, from a seating above it, on to one below, and air is admitted to the branched mounting B. It passes through one pipe from this to the compressor cylinder head, where it forces down a piston C against the action of a spring. Attached to the piston C is a fork which on descending depresses the suction valves and holds them thus while the governor control is maintained. On the piston C being forced down a small port is uncovered, and air under pressure returns to the under side of a differential relay valve in the governor. This tends to draw up the lever under the governor and to re-seat the ball valve on its upper seat, so that when the air receiver pressure falls the connection is cut off, and the pressure above the piston C is relieved. When air under pressure passes to C it also passes along the other branch pipe which communicates with the engine control shown at the top of Fig. 3. Here it forces forward, against

PORTABLE COMPRESSOR SETS.

CONSTRUCTED BY THE GLOBE PNEUMATIC ENGINEERING CO., LTD., ENGINEERS, LONDON.

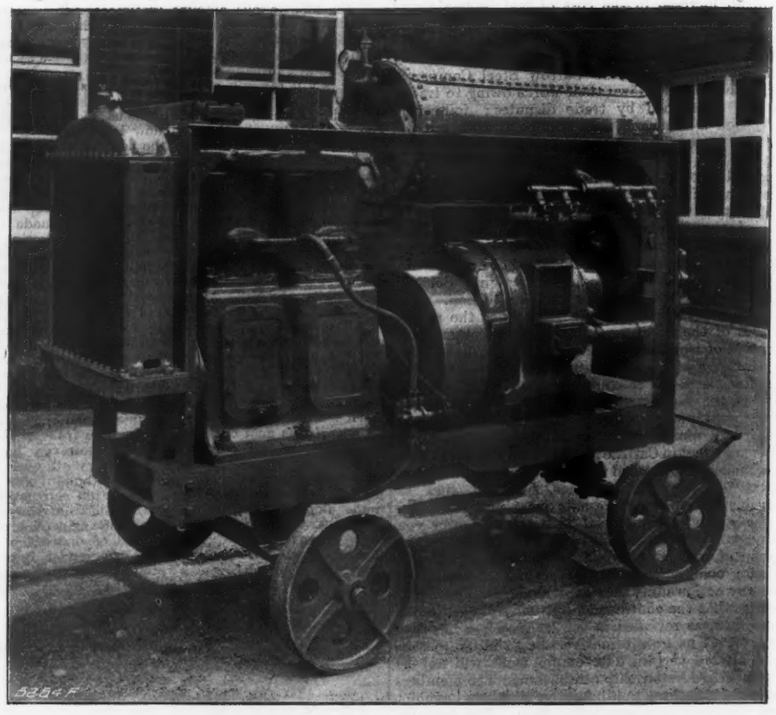


FIG. 1. ELECTRICALLY-DRIVEN PORTABLE COMPRESSOR SET.

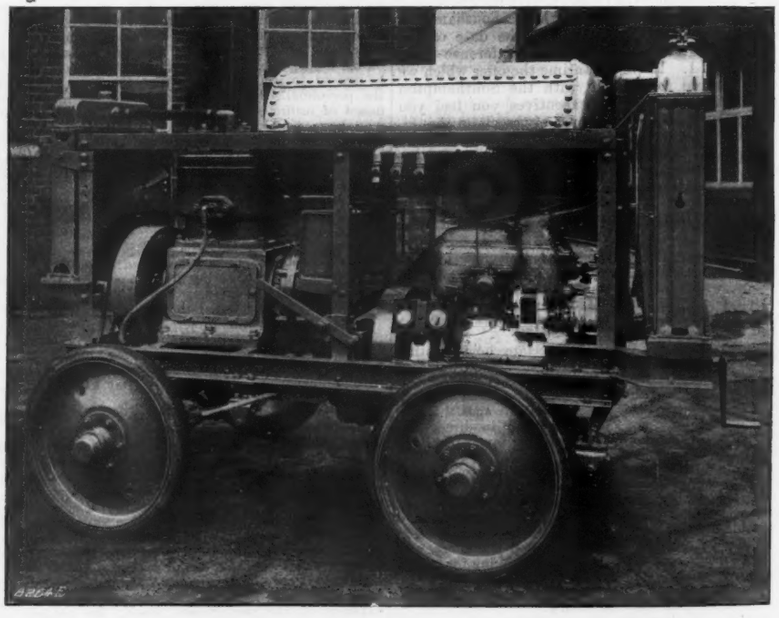
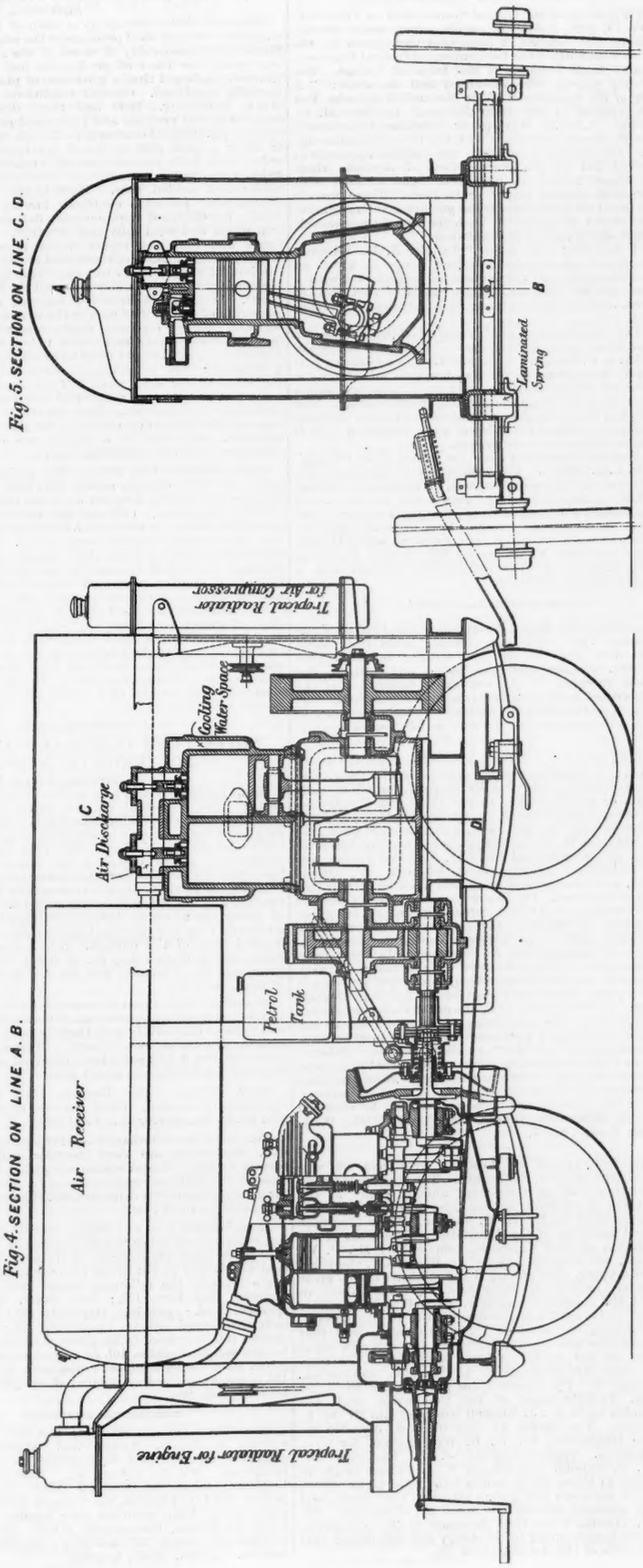


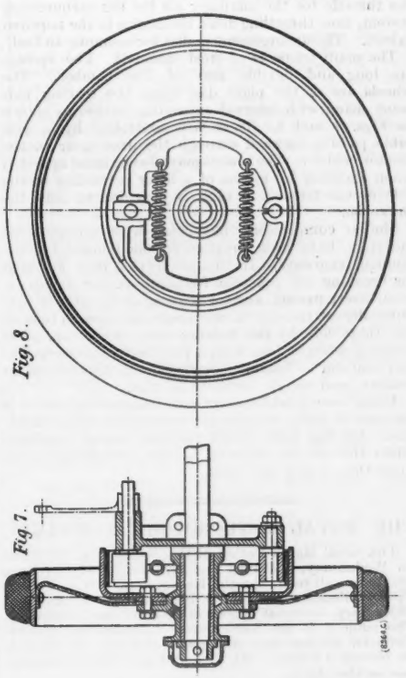
FIG 2. PETROL-DRIVEN LIGHT WEIGHT COMPRESSOR SET.

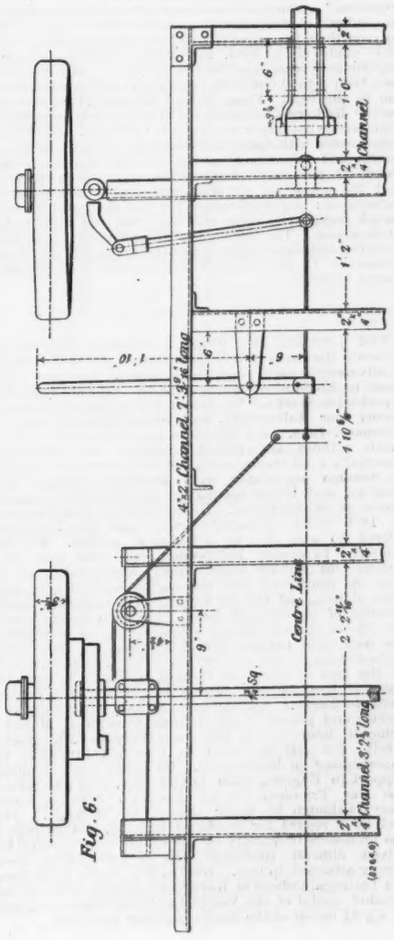
PETROL-DRIVEN LIGHT WEIGHT AIR COMPRESSOR SET FOR THE TROPICS.

CONSTRUCTED BY THE GLOBE PNEUMATIC ENGINEERING COMPANY, LIMITED, ENGINEERS, LONDON.

(For Description, see opposite Page.)







an adjustable spring, a piston which is coupled with the throttle for the auxiliary air for the carburetting system, thus throttling down the engine to the required extent. The arrangement makes for economy in fuel.

The main frame is of steel channels. The springs are long and flexible and of low camber. The wheels are of the plate disc type, the trailing pair being fitted with internal expanding brakes as shown in Figs. 7 and 8. These are controlled by a wire cable passing forward through the draw gear to the tractor vehicle. The brakes may also be hand operated when standing by means of a lever extending to the side of the frame. A rack is provided to hold the brake on.

Similar compressors, but fitted with normal-sized radiators, have been supplied to the London County Council tramways. In this connection they are used for breaking up concrete foundations, for removing granite sett paving, and for dressing down setts *in situ*, especially at the side of worn rails, in order to remove the ridge left by the wearing away of the rail. The dressing down is done with a pneumatic hammer. The sets conform to London County Council regulations for trailers, and weigh complete 35 cwt.

Using two road-breakers and maintaining air at a pressure of 70 lb., the petrol consumption for an eight-hour day has been found to work out at 9 gallons, while the oil consumption for the compressor is no more than ½ pint per week.

THE ROYAL METEOROLOGICAL SOCIETY.

THE usual March lecture of this society was delivered on Wednesday, the 19th inst., in the society's rooms, 49, Cromwell-road, South Kensington, S.W.7, by Mr. V. D. Blackman, Sc.D., F.R.S., Professor of Plant Physiology, Imperial College of Science and Technology. The subject of the lecture was "*Atmospheric Electric Currents, Normal and Abnormal, and their Relation to the Growth of Plants.*" Mr. C. J. P. Cave, M.A., President, was in the chair.

The lecturer pointed out that soon after the experimental proof, in the middle of the eighteenth century, that the atmosphere was electrically charged in calm weather as well as during thunderstorms, the view began to be held that this electrification was of importance in relation to the growth of plants. No certain proof of this was, however, yet available, though its truth was probable. A number of attempts to intensify the normal atmospheric electric current passing to plants by stretching over them fine wires charged to a high potential have been made since 1884, but with conflicting results. Experiments were described which from 1915 onwards have been carried out in the laboratory, with pot-cultures, and in the field. These proved definitely that minute electric discharges increased the rate of growth of cereals, while somewhat larger ones retarded the rate. Of twelve experiments with spring-sown cereals, ten gave positive results and two negative, the average increase being about 22 per cent. Pot-culture experiments showed that the period of the discharge was of the greatest importance; an application for the first and second month being even more effective than one during the whole season. The effect was of the nature of a stimulus, since the additional plant material formed was out of all proportion to the insignificant amount of additional energy supplied.

THE LATE DR. ING. WILHELM SCHMIDT.—We regret to record the death of Wilhelm Schmidt, who did so much to advance the use of superheated steam. He spent some years in England as manager of the English Schmidt-superheater Works. His father was a farmer of small means near Halberstadt, and young Schmidt, born in February, 1858, went from the local school to a locksmith without any higher ambition. He remained essentially a self-trained man. Working later in Dresden, he became acquainted with Professors Zeuner and Lewicki, and found occupation in Ehrhardt's engine works at Wolfenbüttel. He invented a rotary engine in 1879 which attracted notice, and his employer offered to send him to a technical college. But he preferred to remain independent, and was busy perfecting his hot-air engine until—accidentally, it is said—he discovered that the engine continued to run after shutting off the air supply on a relatively small amount of superheated steam. He then concentrated his efforts on superheated steam, going at once from the maximum temperature of 250 deg. C., then tried up to 350 deg. C. (480 and 660 deg. F.). With the support of the firm of Beck and Henkel, of Cassel, he brought out his first tandem engine in 1894; this engine went to Sweden, but was brought back after 25 years' service and placed in the German Museum at Munich. Schmidt later joined the Aschersiebener Maschinenfabrik, but left it again to turn his attention to superheating on locomotives. He found more financial support in England than in Germany, and was before the war President of an American Schmidt company, although he never crossed the Atlantic. He had little regard for academic training, but surprised the professors frequently by the simple way in which he solved difficult problems. His fellow-workers were deeply attached to him. His Dr. Ing. degree came from the Technical College at Karlsruhe; he was holder of the Grashof medal of the Verein Deutscher Ingenieure and of a gold medal of the Berlin Building Academy.

THE OPTICAL SOCIETY.

AT a meeting of the Optical Society held on Thursday, March 13, 1924, a series of papers, experimental demonstrations and exhibits of apparatus were given by the staff and students of the Department of Optical Engineering and Applied Optics of the Imperial College. The following papers were presented and discussed: "*A Study of the Significance of the Foucault Knife-edge Test when Applied to Refracting Systems*," by Miss H. G. Conrady, A.R.C.S. The paper describes experiments made on refracting systems with the Foucault knife-edge test. An attempt to explain the various appearances observed led to the construction of accurate three dimensional models of pencils of light afflicted with aberrations present singly or in pairs. These models were based on equations for the geometric interpretation of the Seidel aberrations. With the aid of these models the test appearances were explained.

"*A Reflecting Spherometer*," by Mr. B. K. Johnson. The optical spherometer described is one in which an auto-collimating method is used in conjunction with a microscope for determining the radius of curvature of convex and concave surfaces, both spherical and cylindrical.

"*The Measurement of Chromatic Aberration on the Hilger Lens Testing Interferometer*," by Mr. R. Kingslake and Dr. L. C. Martin. An account is given of the experimental determination of the longitudinal chromatic aberration and secondary spectrum of telescope object glasses using the Hilger lens testing interferometer. The amount of mirror displacement necessary to give the same interference pattern for different wave lengths of light is measured by a screw micrometer.

"*Note on a Convenient Bench for Testing Object Glasses*," by Dr. L. C. Martin. The arrangement is suitable for the familiar auto-collimation star test. The bench is sloping, so that comparatively large glasses can be taken, and the necessary plane mirror rests safely in its support under gravity and without strain. Fine mercury globules scattered into black velvet form excellent artificial stars when illuminated by condensed light from a Pointolite or gas-filled lamp. The images are observed with a suitable positive eyepiece.

THE IRON AND STEEL INSTITUTE.—The Journal of the Institute, Vol. cviii, now issued, gives the papers which were read at the last autumn meeting, held in Milan, together with the verbal and written discussions thereon. It also contains a description of the works visited by the members in a tour they made through Italy. Together with the abstracts of technical journals and the indexes, the book contains 534 pages.

SCHOLARSHIPS FOR LONDONERS.—The London County Council is prepared to consider applications for the following scholarships from British subjects, provided their parents or guardians live in the County of London:—(1) *Intermediate Technical or Art Scholarships* providing free tuition and, in some cases, a maintenance grant, for students from 16–18 years of age in engineering, technical optics, architecture and building, chemical trades, art, &c. Candidates must possess scientific or artistic ability, and their general education must be up to matriculation standard. (2) *Senior Scholarships in Science and Technology or Art and Artistic Crafts*, providing free instruction at full-time day courses at institutions of University rank or at which advanced instruction in science, technology, art, &c., is given. In some cases a maintenance grant, assessed on the merits of each individual case, will be provided, but it will not exceed 160*l.* a year. Candidates must be not less than 18 years of age. (3) *Free places at the Imperial College of Science and Technology* for candidates at least 18 years of age desirous of taking a post-graduate course in chemistry, engineering, &c. (4) *An "Archibald Dawnay" Scholarship in Civil Engineering* of the value of 110*l.* a year, providing training for two or three years at an approved polytechnic or technical school for a student between 16 and 18 years of age. Particulars may be obtained from the Education Officer, the County Hall, Westminster Bridge, S.E.1.

THE ASSOCIATION OF LONDON STUDENTS OF THE INSTITUTION OF CIVIL ENGINEERS.—The above-mentioned Association held its forty-third annual dinner at the Trocadero Restaurant on the 21st instant, the chair being occupied by Mr. H. H. Mardon, who is Chairman of the Committee of the Association. The toast of the Institution of Civil Engineers, proposed by Mr. P. W. Thomas, was responded to by Mr. Basil Mott, the guest of the evening, who reminded the students of the great traditions behind the Institution and urged them to attend the meetings regularly, as well as to prepare papers to be read and discussed. Dr. H. H. Jeffcott, in proposing the toast of "The Students," said that their number was rapidly increasing and was now equal to the pre-war figure. At the present time, he said, there were 424 students in the London Association. The toast of "The Guests" was proposed by Mr. J. N. Morris, Vice-chairman of the Committee, and was responded to by Mr. J. Mitchell Moncrieff and Mr. W. F. Simonson. The guests, we may mention, included Sir Brodie Henderson, Dr. W. B. Worthington, Sir Cyril Kirkpatrick, Engineer-Captain J. A. Richards, Mr. H. A. D. Acland, and Colonel F. A. Cortez Leigh, in addition to those whose names have been given above. Over 70 members and guests attended the dinner, and a very pleasant evening was spent by all present. Mr. P. W. Thomas is the Hon. Secretary of the Committee, and it is largely owing to his energy and enthusiasm that the success of the Association is due.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Though it is claimed that the gross output of steel and steel products in the neighbourhood of Sheffield is considerably in excess of the average of pre-war years, the basis of production has been so substantially enlarged that a good deal of plant is still only partially employed. General conditions, however, are slowly improving. Here and there departments are engaged at full pressure and have good prospects. The receipt of additional contracts on British railway account is doing a good deal to assist development. Further orders have been placed in South Yorkshire for wheels, axles, tyres, buffer springs, acid steel bars, steel plates, angles and welded bars. Work is also increasing on Government account, contracts having been placed locally for electrical requirements, flat steel wire, cast-iron pipes, and steel rails and crossings. Rolling mills, forges and foundries report rather more active conditions, though makers of crude steel are hampered by the continued indisposition of users in this and other parts of the country to contract forward until the labour outlook clears. Local trouble is also threatened respecting the wage rate of semi-skilled men in the steel and engineering sections. Efforts are being made to secure a joint conference of employers and trade union representatives within the next fortnight so as to avoid the possibility of a stoppage. The improvement previously recorded of the demand for acid steel is fully maintained. The output of an increased number of furnaces is going into immediate consumption. More electric steel, light castings and fittings are on order for the British automobile industry, and there is a steady run on excavating machinery and road-repairing tools.

South Yorkshire Coal Trade.—The position has undergone very little change, except that with the advent of warmer weather the demand on house coal supplies has slightly diminished. Collieries and merchants, however, are still very much in arrear with deliveries, and there is no sign of movement towards lower prices. Railway companies are taking a large share of the output of best steams; the export demand is less robust. The small tonnage of cobbles, nuts, and slacks available for open market disposal is eagerly snapped up at remunerative rates. Quotations:—Best branch handpicked, 36*s.* to 39*s.*; Barnsley best silkstone, 34*s.* to 36*s.*; Derbyshire best brights, 31*s.* to 35*s.*; Derbyshire best house, 27*s.* to 29*s.*; Derbyshire best large nuts, 27*s.* to 28*s.*; Derbyshire best small nuts, 20*s.* 6*d.* to 23*s.*; Yorkshire hards, 27*s.* to 30*s.*; Derbyshire hards, 25*s.* to 28*s.*; rough slacks, 12*s.* 6*d.* to 15*s.* 6*d.*; nutty slacks, 12*s.* to 14*s.*; smalls, 8*s.* to 10*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The feeling is becoming general that Cleveland pig-iron prices have sunk to levels at round about which stabilisation may be reasonably expected, and this is emphasised by expansion of home and foreign business. Not only has continental competition almost vanished, but buyers abroad who have not done business here for a long time are once more entering the market. Heavy transactions have been put through and, indeed, makers are stated to have disposed of nearly the whole of their rather large stocks. Quite a cheerful tone now prevails, traders taking a much more hopeful view of the outlook. No. 1 Cleveland pig is scarce and is quoted 94*s.* 6*d.* to 95*s.*; No. 3 g.m.b. is 91*s.*; and No. 4 foundry and No. 4 forge are each 90*s.*, all f.o.t. and f.o.b.

Hematite.—East Coast hematite is inclined to stiffen. In this branch also producers are understood to have sold their stocks extensively and there is not a great deal of iron to offer for prompt delivery. Makers ask 100*s.* for Nos. 1, 2 and 3, but sales have occurred at 99*s.* No. 1 is put at sixpence above mixed Nos.

Blast Furnace Coke.—Durham blast furnace coke continues to weaken. Good average qualites are now 27*s.* 6*d.* to 30*s.* delivered to local users.

Furnace Coke.—Durham blast furnace coke is slow of sale. Quotations are very irregular and inclined to further weaken. Local consumers claim they can purchase to satisfy their requirements at round about 27*s.* 6*d.* for good medium sorts delivered, but there are sellers who still name up to 31*s.* 6*d.*

Manufactured Iron and Steel.—Several firms are busy but contracts are being rapidly completed, and orders to take their place are difficult to secure. Manufacturers continue keenly to cut prices for overseas trade, but for home business the following agreed rates still rule:—Common iron bars, 12*l.*; iron rivets, 14*l.*; packing (parallel), 9*l.*; packing (tapered) 12*l.*; steel billets (soft) 9*l.*; steel billets (medium), 10*l.*; steel billets (hard), 10*l.* 5*s.*; steel boiler plates, 13*l.* 10*s.*; steel ship, bridge, and tank plates, 10*l.* 5*s.*; steel angles, 10*l.*; steel joists, 10*l.*; heavy sections of steel rails, 9*l.*; fish plates, 13*l.*; and galvanised corrugated sheets (24-in. gauge, in bundles), 18*l.* 10*s.*

PERSONAL.—On and after the 31st inst., the London address of Messrs. Ruston and Hornsby, Limited, engineers, Lincoln, will be Imperial House, 15 to 19, Kingsway, W.C.2. Telegrams: Ruston, Westcent, London; telephone, Gerrard 5866.—Messrs. Hurst, Nelson and Co., Limited, the Glasgow rolling stock and plant works, have removed their London office to 32, Great St. Helens, Bishopsgate, E.C.3. Their telephone numbers are Avenue 2620 and 2621; and their telegraphic address, "Lintel, Stock, London."

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—The Scottish steel trade has shown no change for the better over the week, and some difficulty still exists in keeping plant moving. The labour world is so unsettled that buyers are far from disposed to commit themselves at the present time, and until the horizon becomes clearer consumers are unlikely to enter the market. Immediate requirements are about all that are being specified for just now, and even inquiries show a falling off. Prices have been keeping steady, but the opinion was very general recently that a reduction was certain, and the decision of producers to make no change meantime has not been viewed with favour. Whether or not this will lead to a little more buying remains to be seen. Export business continues slow and the prices being accepted for anything on offer are so keen that very little margin is left. In the black-sheet trade makers have still a fair amount of work on hand, and each week sees the addition of a few more lines, with the result that employment over all is keeping very steady. Makers of steel for constructional purposes have a fair tonnage booked, and there are one or two fresh inquiries in the market. There are also some fair lots of railway material being inquired about for India. Prices are steady as follow:—Boiler plates, 13*l.* 10*s.* per ton; ship plates, 10*l.* 5*s.* per ton; sections, 10*l.* per ton; and sheets, $\frac{7}{8}$ in. to $\frac{1}{4}$ in., 12*l.* 10*s.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—The position of things in the West of Scotland malleable-iron trade has not changed and is not very satisfactory at the moment. Improvement cannot be looked for so long as labour unrest is so rife, and added to this of course is the unsettled state of the foreign markets. Producers are scarcely booking any good orders meantime, and the works are being kept running on old contracts. Prices are unchanged with "Crown" bars called 12*l.* 10*s.* per ton, delivered Glasgow stations.

Scottish Pig Iron Trade.—A dull tone prevails in the Scottish pig-iron trade, and fresh orders of any importance are not easily secured. The output at the present time is very small, and in spite of this the stocks in some places are increasing. Inquiries are not numerous, and whenever there is the least chance of a good line sellers are prepared to give very favourable quotations. The demand for hematite iron is not heavy, but a few export lots have lately been picked up as also a few for foundry grades. Prices have all an easier tendency, and the following may be taken as the current quotations: Hematite, 5*l.* 2*s.* 6*d.* per ton, delivered at the steel works: foundry iron, No. 1, 5*l.* 5*s.* per ton, and No. 3, 5*l.* per ton, both on trucks at makers' yards.

Scottish Pig-Iron Shipments.—The shipments of Scottish pig iron from the Glasgow Harbour for the week ending last Saturday, March 22, amounted to 1,111 tons. Of that total 938 tons went foreign and 173 tons went coastwise. For the corresponding week of last year the figures were 2,385 tons to foreign destinations and 182 tons coastwise, making a total shipment of 2,567 tons.

Shipbuilding.—It is reported that Messrs. John Brown and Co., Clydebank, have secured orders from the Great Western Railway to build two passenger steamers for the Channel Island route.

AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS.—The volume of Proceedings of this Institute, containing the papers and discussions at the meetings held in New York and Canada in 1923, Vol. lxix of the series, is a most interesting book of over 1,300 pages, clearly printed and illustrated. The papers number 63, dealing with mining, ferrous and non-ferrous metallurgy and include one by Dr. Rosenhain on "Solid Solutions." It is published by the Institute, 29, West 39th-street, New York.

EMPIRE MINING AND METALLURGICAL CONGRESS.—H.R.H. Prince Arthur of Connaught will be the principal guest at the official banquet of the Empire Mining and Metallurgical Congress, to be held at Guildhall on Thursday, June 5. The Lord Mayor and other distinguished guests will also be present, including official delegates from all parts of the Empire. The sessions of the Congress will be held at the British Empire Exhibition from June 3 to 6 inclusive, for which the various conference halls have been placed at the disposal of the convening bodies by the Exhibition authorities.

CONTRACTS.—The British Mannesmann Tube Company, Limited, Baldwin House, 67, Queen Victoria-street, E.C. 4, has received the contract for the supply of welded and riveted steel pipes and specials in connection with the Tata Power Company's Nila-Mula, or Bhira (India), hydro-electric scheme. The order will be executed at the British Mannesmann Company's works at Newport. The pipe-line at its head consists of three lines of 84-in. internal diameter riveted pipes, bifurcating into six lines of riveted pipes, reducing from 58$\frac{1}{2}$ in. to 54$\frac{1}{2}$ in. diameter, followed by the lap-welded pipes, six lines of 54 in. diameter, up to $\frac{1}{2}$ in. thick, reducing to 51 in. diameter, up to 1 in. thick, and finally branching into twelve lines of 36-in. pipes up to 1$\frac{1}{4}$ in. thick, supplying water to twelve impulse wheels. The approximate length of the pipe-line, from tunnel mouth to power house, is 5,850 ft.; the maximum head of water is 1,672 ft., equal to a pressure of 725 lb. per square inch. The approximate total weight of the pipes and specials is 9,000 tons.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—New business on the coal market has been curtailed because of the tightness of colliery steamers and the consequent difficulty experienced by merchants in arranging for further cargoes. The difficulties of operators are further complicated by the absence of third shift working at the docks, and the fact that from 25 to 30 vessels are waiting for tips. A move is again to be made with a view to securing a resumption of night work, for officials of the Great Western Railway are meeting representatives of the coal tippers on Friday to discuss the matter. The uncertain outlook regarding the prospect of a coal strike in April is also causing operators much anxiety, and there is a general disposition to cover at least part of their requirements. Prices generally are steady, on the basis of 32*s.* to 33*s.* for best Admiralty large coal, and from 22*s.* 6*d.* to 23*s.* 6*d.* for best steam smalls.

Contracts for New Ships.—It is significant that some of the old established Cardiff firms and people who have been in the shipping business for a considerable number of years and during the post-war period have been content to look on, have apparently come to the conclusion that the time has arrived when steps should be taken to extend their present fleets. Messrs. John Long and Sons, Limited, Cardiff, have ordered a new steamer of 8,300 tons deadweight, to be built by Messrs. Wm. Gray and Co., Limited, and engined by the Central Marine Engine Works, West Hartlepool, to be delivered in December next. Already this year Cardiff owners have contracted for half-a-dozen new steamers, totalling over 45,000 tons, while a number of second-hand ships have been acquired. During the past week Messrs. Lewis Surgher and Co. bought the steamer King Edward, 7,300 tons deadweight, from the King Line, London; Messrs. Turnbull Bros. (Cardiff), Limited, bought the Norwegian steamer Diammensfjord, 7,500 tons, and the Burnham Shipping Company, Limited, acquired the Glasgow steamer Inveresh, 2,170 tons.

Iron and Steel Trades.—Exports of iron and steel goods last week amounted to 21,205 tons, compared with 18,871 tons in the previous week. Shipments of tinplates and terneplates totalled 8,835 tons, against 8,750 tons; blackplates and sheets to 7,462 tons, against 3,901 tons; galvanised sheets to 3,437 tons, against 2,138 tons; and other iron and steel goods to 1,471 tons, against 4,082 tons.

CANADIAN AERODYNAMIC LABORATORY.—A new aerodynamic laboratory in the Department of Mechanical Engineering of the University of Toronto has recently been opened, states H.M. Trade Commissioner at Toronto. The building, which will house the wind channel, will permit research in aerodynamics and allied subjects the whole year round, instead of only during the summer months. The channel, which was formerly housed in the hydraulic laboratory, has been altered, and now permits speeds up to 90 ft. per second in the working section. This is the only equipment of its kind in Canada, and it is frequently made use of by the Royal Canadian Air Force to secure data of proposed designs, and by manufacturers for various test work.

ELECTRIC TELEVISION.—The interesting point in the discourse on the "Possibility of Electric Television," which Mr. A. A. Campbell Swinton, F.R.S., delivered before the Radio Society, last Wednesday, was the proposed utilisation of the cathode-ray oscillograph of Braun. The cathode-ray beam having no perceptible momentum can be deflected by electric or magnetic fields so as to trace a current curve at a frequency unattainable by ordinary oscillographs, and synchronism between the transmitting and receiving beams can again be secured without mechanically-moved parts. In Mr. Swinton's receiver the narrow cathode-ray beam—which was in his first arrangement of sixteen years ago, produced by a high-tension battery—falls on a screen, built up of a large number of small insulated metallic photo-electric cells, the whole mounted in a chamber containing sodium vapour. On the other side of the screen is the lens projecting the image into the transmitter, and between the lens and the screen is a diaphragm of metallic gauze joined to the line wire. The beam is deflected, vertically and horizontally by the electro-magnetic fields, produced by two alternating-current generators; each generator circuit comprises a corresponding magnet in the receiving end. The cathode-ray beam sweeping over the screen imparts a negative charge to each cell on which it falls; if the light from the lens strikes one of the cubes, it liberates the electrons, which, caught by the gauze diaphragm, send a current impulse over the line wire to the receiver. The receiver is constructed like the transmitter, but it has no photo-electric cells, and its cathode-ray beam travels over a fluorescent screen or other device. Within a fraction of a second this screen becomes covered with a number of luminous spots corresponding to the luminous image thrown into the receiver. The original arrangement required in addition to the line wire, two synchronising wires for the two generator circuits. By gearing the two generators of each pair for a constant frequency ratio one wire could be dispensed with; radiotelegraphy and amplifiers have made all line wiring dispensable and instead of the high-tension battery for producing the cathode-ray beam, a hot wire Wehnelt cathode, heated by a battery of a few hundred volts, can be used. Mr. Swinton did not expect to solve the problem of television within a year as others have done. The many photo-electric cells are complex; but each of them is independent of the others.

NOTICES OF MEETINGS.

THE ROYAL SOCIETY OF ARTS.—Monday, March 31, at 8 p.m., at John-street, Adelphi, W.C. 2. Cobb Lecture, "Certain Fundamental Problems in Photography," by T. Slater Price, O.B.E., D.Sc., Ph.D., F.I.C. (Lecture II). Wednesday, April 2, at 8 p.m. Ordinary Meeting. "London Traffic," by Sir Lynden Livingstone Macassey, K.B.E., LL.D., D.Sc. Friday, April 4, at 4.30 p.m. Special Meeting. "The Amazon Valley and its Development," by George Macaulay Booth.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, April 1, at 6 p.m., at Great George-street, S.W.1. Ordinary meeting. Papers to be submitted for further discussion: "The Interaction in Bridgework of the Deck System on the Main Girders, and the Consequent Modification of Stresses Therein," by Mr. Douglas Henry Remfry, B.Eng., Assoc.M.Inst.C.E.; "Theory of Transverse Oscillations in Girders and its Relation to Live-Load and Impact Allowances," by Professor Charles Edward Inglis, O.B.E., M.A., M.Inst.C.E. Students Meeting, Wednesday, April 2, at 6 p.m. Cinematograph lecture on "The Manufacture of Solid-Drawn Steel Tubes," by Eng.-Capt. J. A. Richards, R.N.

THE LIVERPOOL ENGINEERING SOCIETY.—Wednesday, April 2, at 8 p.m., at 9, The Temple, Date-street, Liverpool. "Some Aspects of the Scientific Control of Steam Generation in Factories," by Mr. H. S. Rowe, B.Sc., M.Inst.C.E.

THE INSTITUTION OF ELECTRICAL ENGINEERS: WIRELESS SECTION MEETING.—Wednesday, April 2, at 6 p.m., at Savoy Place, Victoria Embankment, W.C. 2. "Thermionic Valves with Dull-Emitting Filaments," by the Research Staff of the General Electric Company, Limited. (Work conducted by Messrs. M. Thompson and A. C. Bartlett.)

THE INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—Wednesday, April 2, at 7 p.m., at the Engineers' Club, Coventry-street, W.1. "Lay-out of Kitchens in this Country and America," by Mr. Stanley J. Benham.

THE ROYAL AERONAUTICAL SOCIETY.—Thursday, April 3, at 5.30 p.m., at the Royal Society of Arts, John street, Adelphi, W.C. 2. Lecture: "The British Aviation Mission to the Imperial Japanese Navy," by Colonel the Master of Sempill, A.F.C.

THE BIRMINGHAM METALLURGICAL SOCIETY.—Thursday, April 3, at 7.15 p.m., at the Assembly Room, Chamber of Commerce, New-street, Birmingham. Paper: "Electric Furnaces," by Mr. A. G. Lobley, M.Sc.

THE SOCIETY OF CHEMICAL INDUSTRY: BIRMINGHAM SECTION; AND THE CHEMICAL ENGINEERING GROUP.—Friday, April 4, at 6.30 p.m., in the White Horse Hotel, Congreve-street, Birmingham. "The Premier and other Colloid Mills and their Applications in Industry," by Capt. F. J. China.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, April 4, at 7 p.m., at Storey's Gate, S.W.1. Informal Meeting. Resumed discussion on "Mechanical Methods of Boiler Firing."

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, April 4, at 7.30 p.m., at 39, Victoria-street, S.W. 1. Lecturette: "Mineral Oils, with Special Reference to Lubricating and Insulating Oils," by Mr. A. J. Sear, A.R.C.S.

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, April 4, at 7.30 p.m., at Bolbec Hall, Newcastle-on-Tyne. "Various Aspects of Internal-Combustion Engines," by Engineer-Commander C. J. Hawkes, R.N. (ret.).

THE INSTITUTE OF BRITISH FOUNDRYMAN: LANCASHIRE BRANCH.—Saturday, April 5, at 3 p.m. Annual general meeting. Paper on "Semi Steel," by Professor A. Campion, F.I.C., F.C.S.

THE INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—A meeting of this Institution is to be held on Saturday, April 5, in the Council Chamber, Town Hall, Rotherham.

THE LOCOMOTIVE ENGINEERS' POCKET BOOK, 1924.—The nature of this little work is so well known that it needs little recommendation to draughtsmen and others interested in locomotive matters. It has now run through so many annual editions, most of which have seen the introduction of improvements, that the material has been reduced to a most practical quality. Changes, however, are still possible as the years go by, and it is pleasant to be able to record that timely notes are being introduced on later developments while some of the material which is becoming of less interest is being dropped. There are useful tables on the loads on journals, crank pins, &c. Balancing now secures greater attention than formerly, but we do not understand why tables of dimensions of Colonial locomotives should be inserted into this section instead of being kept with similar tables for the railways of the United Kingdom. The tables relating to wire ropes will prove serviceable in lifting, while the notes on various types of tentative developments with turbines, and Diesel and other engines, will probably, in years to come, expand into quite a material section of the work. The book is brought out by the Locomotive Publishing Company, Limited, 3, Amen-corner, Paternoster-row, E.C.4, at 3*s.* 6*d.* net.

THE OXYTOME METAL-CUTTING MACHINE

CONSTRUCTED BY MESSRS. ALFRED HERBERT, LIMITED, ENGINEERS, COVENTRY.

(*For Description, see Page* 411.)

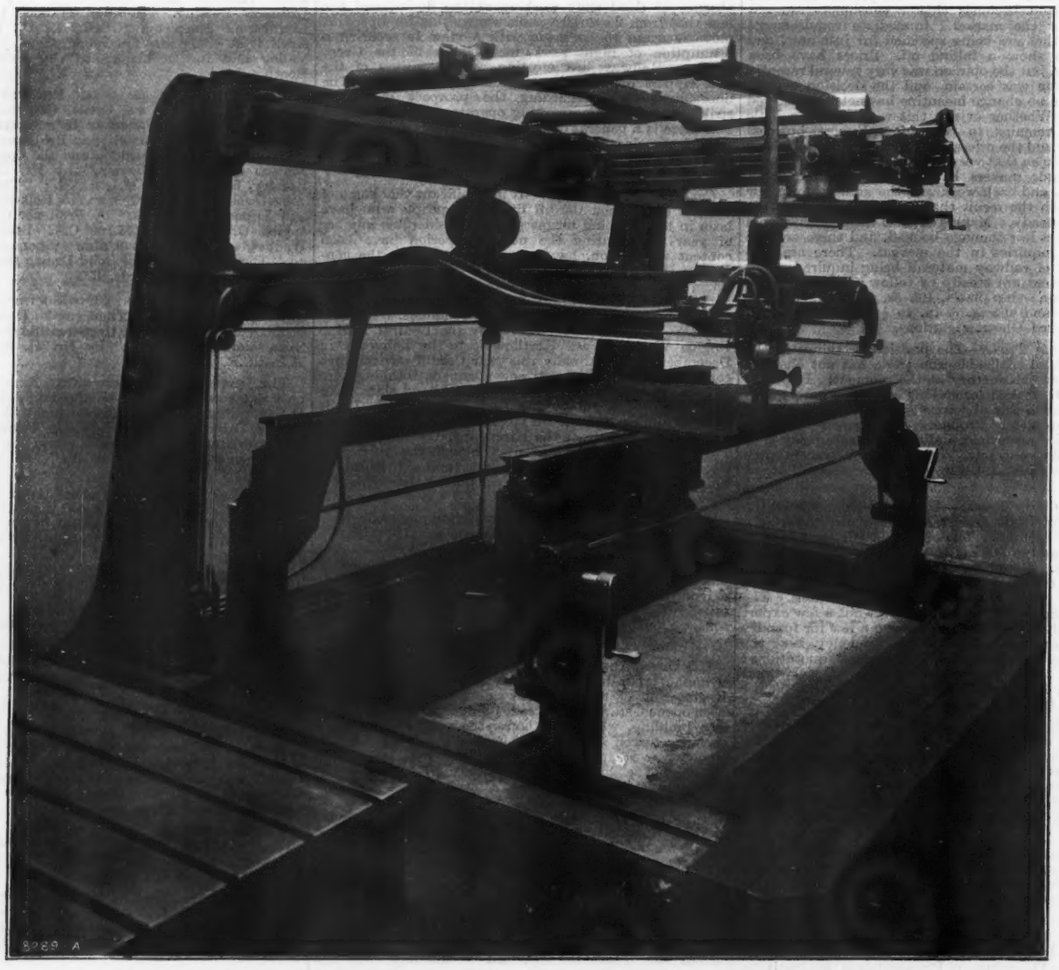


FIG. 1. GENERAL VIEW OF MACHINE ARRANGED FOR CONTOUR CUTTING.

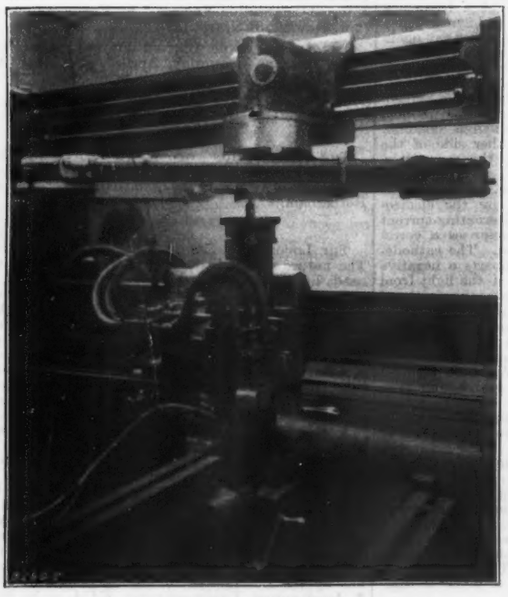


FIG. 2. CUTTING HEAD ARRANGED FOR CIRCULAR CUT.

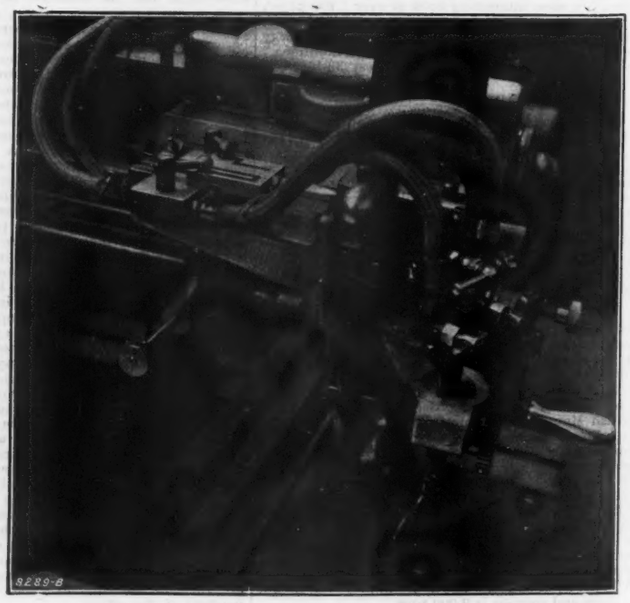


FIG. 3. VIEW OF TORCH.

THE POWER STATION OF TH BRI

(For Descripti Page 3

Fig. 28. View of Boiler-Room from Machinery Hall.

Fig. 29. Boilers Constructed by John Thompson Water Tube Boilers, Limited, under Erection.

BRITISH EMPIRE EXHIBITION.

(For Description, see Page 387.)

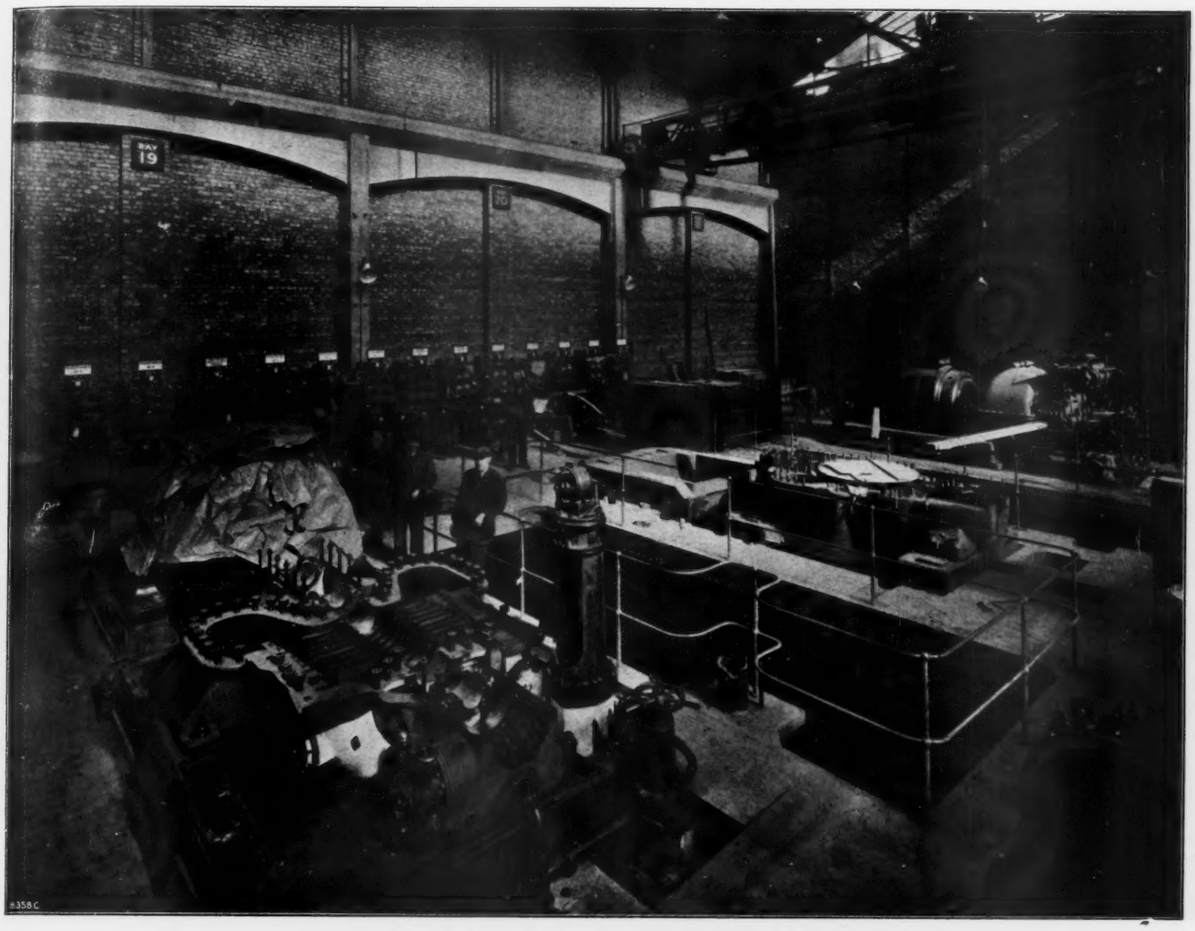


FIG. 30. VIEW OF ENGINE-ROOM WITH MACHINERY UNDER ERECTION.

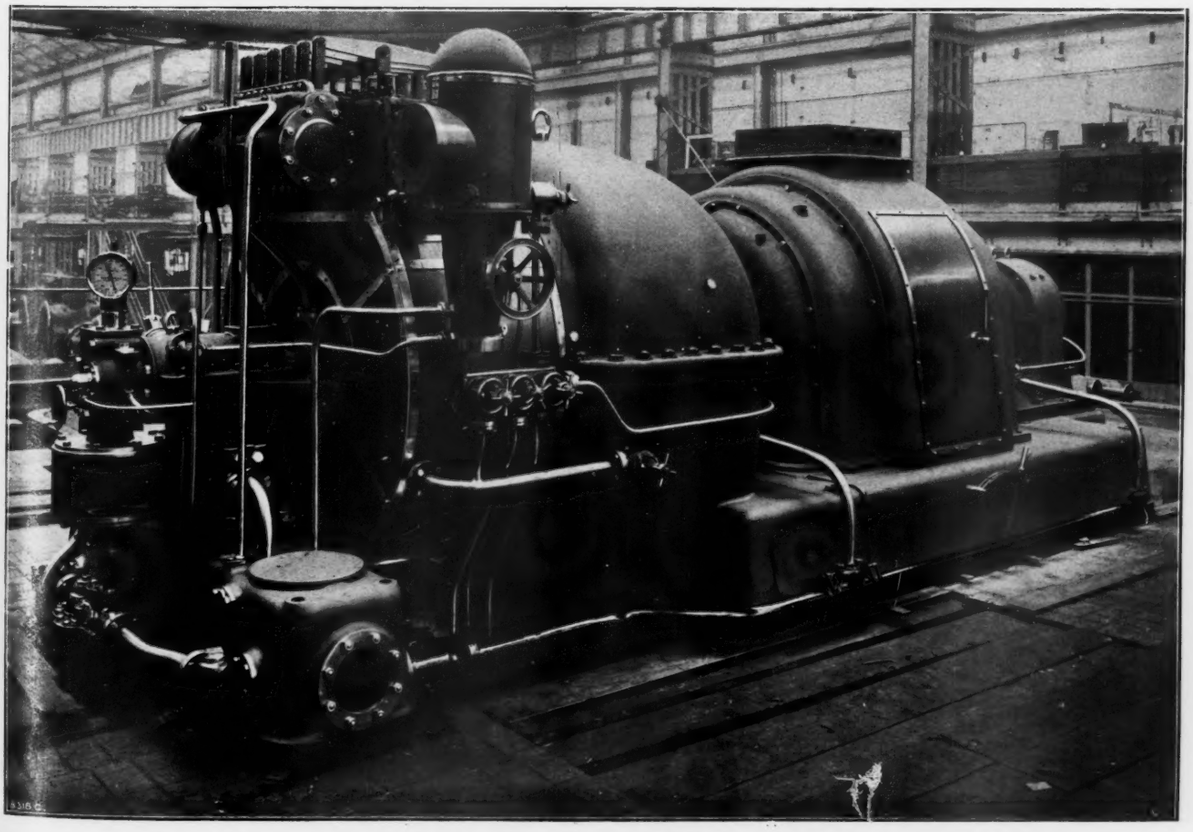


FIG. 31. 1,500-KW. TURBO-ALTERNATOR CONSTRUCTED BY THE BRITISH THOMSON-HOUSTON COMPANY, LIMITED.

ENGINEERING.

Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand, London, W.C.2.

We desire to call the attention of our readers to the fact that the above is our **SOLE ADDRESS**, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.

TELEPHONE NUMBERS—3663 and 8598 GERRARD.

SUBSCRIPTIONS, HOME AND FOREIGN.

"ENGINEERING" may be ordered from any newsagent in town and country and at railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

For the United Kingdom	£3	5	0
For Canada—			
Thin paper copies	£2	18	6
Thick paper copies	£3	3	0
For all other places abroad—			
Thin paper copies	£3	3	0
Thick paper copies	£3	7	6

Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

When foreign subscriptions are sent by Post Office Orders, advice should be sent to the Publisher.

ADVERTISEMENT RATES.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shilings for the first four lines or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12*s.* per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received 10 days previous to the day of publication.

All accounts are payable to ENGINEERING, LTD. Cheques should be crossed "The National Provincial Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford Street, Strand, W.C. 2.

AGENTS FOR "ENGINEERING."

AUSTRALIA: Gordon and Gotch, Limited, Melbourne; Sydney; Brisbane; Perth. Angus and Robertson, Limited, Sydney, N.S.W. T. Willmett and Co., Townsville, North Queensland. W. C. Rigby, Adelaide, South Australia. Melville and Mullen, Melbourne, Victoria.

BELGIUM, Brussels: E. F. Satchell, 86, Rue du Tabellion.

CANADA, Toronto, Ont.: Wm. Dawson and Sons, Limited, 87, Queen Street, East.

EDINBURGH: John Menzies and Co., Limited, Rose-street.

FRANCE, Paris: Boyveau and Chevillet, 22, Rue de la Banque. For Advertisements, Office de Publications Commerciales, 167 Rue Montmartre, Paris (2e).

GERMANY: Hermann H. Fromm, Potsdamerstr 105A, Berlin, W. 35. A. Twietmeyer, Leipzig.

GLASGOW: William Love, 221, Argyle-street. John Menzies and Co., Limited, West Nile-street.

INDIA, Calcutta: Thacker, Spink and Co., Bombay; Thacker and Co., Limited.

ITALY: U. Hoepli, Milan. Anonima Libraria Italiana, Torino. And any post office.

LIVERPOOL: Mrs. Taylor, Landing Stages.

MANCHESTER: John Heywood, 143, Deansgate.

NEW ZEALAND: Gordon and Gotch Proprietary, Limited, Wellington, Auckland and Christchurch.

NORWAY, Christiania: Cammermeyer's Boghandel, Carl Johans Gade, 41 and 43,

ROTTERDAM: H. A. Kramer and Son, Limited.

SOUTH AFRICA: Central News Agency, Limited, Head Office—Johannesburg; and Pretoria, Cape Town, Port Elizabeth, Bloemfontein, Durban, and various branches and bookstalls throughout South Africa. Wm. Dawson and Sons, (South Africa), Limited, 29, Long-street, Capetown.

TASMANIA: Gordon & Gotch Prop'ty, Ltd., Launceston: Hobart.

UNITED STATES: For Subscription, New York: W. H. Wiley, 440, Fourth Avenue. For Advertisements: J. S. Allan, 30, Church-street, New York.

CONTENTS.

	PAGE
The Properties of Gases in High and Low Vacua (*Illus.*)	387
The Power Station of the British Empire Exhibition (*Illus.*)	387
The Principle of Dynamical Similarity, with Special Reference to Model Experiments (*Illus.*)	391
The French Navy	393
The Action of Frost on Ciment Fondu	393
Ignition Equipment for a 7,500-H.P. Gas Engine (*Illus.*)	394
Joist and Girder Bracket Clip (*Illus.*)	395
Notes on New Books	395
Industrial Notes	396
Letters to the Editor.—"Production Costs in the Engineering Industry." "Fuel Consumption of Motor Ships."	397
Portable Compressor Sets (*Illus.*)	398
Royal Meteorological Society	400
The Optical Society	400
Notes from South Yorkshire	400
Notes from Cleveland and the Northern Counties	400
Notes from the North	401
Notes from the South-West	401
Notices of Meetings	401
Modern Power Station Practice	403
Airship Development	404
Horse and Motor Haulage	405
Damage to Cargo: Seaworthiness	405
The Late Dr. R. E. Froude	406
The Tram Strike and Metropolitan Traffic	406
Notes	407
Literature.—Acoustics of Buildings, including Acoustics of Auditoriums and Sound Proofing of Rooms	408
Books Received	409
The Late Mr. Henry Deane	409
The State of the Electrical Industry	409
Palmer-Camellaird-Fullagar Oil Engine	409
Portable Logging Saw and Petrol Engine (*Illus.*)	410
The Oxytome Metal-Cutting Machine (*Illus.*)	411
The Institution of Mechanical Engineers (*Illus.*)	412
Powdered Coal: Its Preparation and Utilisation (*Illus.*)	415
ENGINEERING Patent Record (*Illus.*)	419

Two-Page Plate.—THE POWER STATION OF THE BRITISH EMPIRE EXHIBITION.

ENGINEERING.

FRIDAY, MARCH 28, 1924.

MODERN POWER-STATION PRACTICE.

IN his address last Friday as President of the Institution of Mechanical Engineers, Mr. Patchell observed most of the rules which should, but by no means always do, govern the discourse of men on the occasion of their election to a presidential chair. The perfect Presidential address should deal on broad lines with a subject of particular interest to the members of the Institution at the time, and especially should it voice knowledge and opinions which could not be expressed with greater authority by anyone other than the speaker. Mr. Patchell's long experience of power-station work and his intimate acquaintance with its recent developments, especially on the other side of the Atlantic, give his observations a special weight, and his address, which we reprint in abstract elsewhere in this issue, contains very much food for thought on the part of those responsible for the development of electric-power supply in this country.

No one who reads the address can fail to be struck by the comparison between American power stations and our own. In the first place, the Americans have much larger stations than we have, and these stations contain generating units of a capacity greater than exist in this country. These facts are, of course, related to each other, for an increase in the size of individual units is the only alternative to an unreasonable number of smaller machines and boilers to provide the output for which the large stations are constructed. There is no reason to believe that, if the business of electricity supply had developed in Great Britain to the same extent as in America, there would be any material difference either in the size of the power stations or in the rated capacity of the generating units in the respective countries. The reasons which may be adduced for our relative backwardness are numerous. The powerful position already established by the gas industry when electricity came on the scene was undoubtedly a factor in the case, but even that was not so detrimental as the absurd legislation which confined electricity supply to parochial areas and conferred upon little local authorities powers which they used very largely to prevent the introduction of electricity at all. The legal difficulties and expenses of getting a scheme through Parliament, which was sure to be opposed on principle by every municipality directly or remotely concerned, prevented the work being undertaken by companies such as those to whom the electrical development of America is almost entirely due. Added to these were the needless restrictions upon overhead transmission, even in country or moorland areas, which even now are not wholly removed.

The appointment of the Electricity Commissioners in 1920 raised hopes that at last the supply of electricity would be organised in a manner necessary to the welfare of the country, and although the results so far attained do not appear very striking, the situation is certainly improved by their existence. The outstanding fact to be borne in mind is that the potential demand for electricity in this country is enormous. Our population may be somewhat less than half that of the United States, but it is much more highly industrialised and urban, and consequently ought to consume more electricity per head than is used in the States. Nothing approaching this is, of course, the case. We have scores of quite considerable towns with no electricity supply at all, and even in large cities noted for their industrial activities the consumption per head is far less than is attained by the small prairie towns in Western Canada, where from 300 to 400 kw.-hours per annum is quite commonly absorbed for every individual in the population. Mr. Patchell appears to blame the lack of energy of the selling departments of our electric-light undertakings for this state of affairs, and there is much truth in this view. But the best salesman in the world cannot make people buy electricity when there is no supply in the street, and a little more enterprise in putting down cables ahead of demand, and quoting simple and intelligible rates, which moreover should be so low as to be hardly remunerative until the demand is obtained, would do much to stimulate the consumption of electricity and enable still lower rates to be charged.

It will be noted in the tables which we have reproduced in part, that Mr. Patchell has arranged the principal power stations in Great Britain and the United States respectively in the order of their reputed thermal efficiencies. He warned his hearers against comparing the figures too closely as between stations with different load-factors, but we would deprecate comparison for quite other reasons. While it must be admitted that thermal efficiency is the only proper basis of comparison from the technical as distinguished from the commercial point of view, before the comparison can be worth anything we must be assured not only that the determinations of the calorific value of the fuel, on which the figures are based, are reliable, but also that the computations have all been made in the same way. The discrepancies which may exist between the calorimetric results of samples even the same coal when tested by different chemists are notorious, while even if agreement be reached as to the proper calorimeter readings, there are various ways in which the calorific value may be stated and used. Some engineers allow for moisture only, others make deductions for the hydrogen-content as arrived at either by analysis or assumption, while, apart from these variations in practice, there is no general agreement as to what flue-gas temperature shall be taken in computing the available heat of the products of combustion. The consequence of these multifarious sources of uncertainty is that many engineers are somewhat contemptuous of all figures of thermal efficiency unless they are satisfied, firstly, as to the real calorific value of the coal, and secondly, as to method of computation employed. It would be of inestimable benefit if the Institution over which Mr. Patchell presides would with our engineering institutions make an authoritative pronouncement upon the way in which thermal efficiencies should be determined,

as until this is done no effective comparisons are possible between different stations.

The high thermal efficiencies claimed for the American stations do not carry the weight they would if it were certain that they were really comparable with the British results. We gather, from Mr. Patchell's warning, to which we have referred, that he attributes high thermal efficiencies largely to the existence of good load factors. This is a very common belief but, as we have pointed out on other occasions, there seems to be no ground for such an assumption, and indeed all the evidence goes to show that load-factor by itself has no influence at all upon the thermal efficiency of a station. The annual coal consumption of a given plant, producing a given annual output, will be quite independent of the uniformity or otherwise with which the output is generated. The point is the subject of so much misunderstanding that we will illustrate it in some detail.

In our recent analysis of the operating results of the Blackburn power station we showed that the coal consumption of that station in pounds per eight-hour shift could be accurately represented by the Parsons coal line, to which the equation was $C = 18{,}600 + 1{\cdot}540\ K$. in which K denoted the electrical output during the period. For a whole year the coal consumption would therefore be $C = (18{,}600 \times 3 \times 365) + 1{\cdot}540\ K.$, the letter K now denoting the year's output of electricity. It does not matter how this quantity of electricity is turned out, whether at a steady rate corresponding to a load-factor of 100 per cent., or whether it is made up of heavy evening and winter peaks with intervals of light load between. It is clear from the equation that the question of load-factor does not enter into the matter, and so long as other conditions remain unchanged, the only way to reduce the coal consumption per kilowatt-hour is to increase the total output. Whether the extra load comes on the peak, or at other times, is quite immaterial so far as coal consumption is concerned. This deduction which cannot be controverted as it follows mathematically from the linear nature of the characteristic equation, emphasises the primary importance of an active campaign for the sale of electricity.

The real value of a high load factor lies in its effect in cheapening electricity by reducing the capital cost of the power plant and mains for a given annual output. In this respect it is vastly important, for heavy capital charges per unit generated are a drag on any electrical undertaking, which may easily outweigh the best possible efficiency of operation. The higher the load-factor the more it is commercially justifiable to spend in construction and equipment for the sake of promoting efficiency. Mr. Patchell, unfortunately, did not give capital charges or operating costs in connection with the large American stations to which he drew attention nor did he mention the average price obtainable for current. Such stations as those to which he referred cannot in the nature of things be built cheaply, and interest on their cost must be a considerable item in the price of the electricity produced. He hints at the magnitude of the "church-like" structures now being built and the phrase is no exaggeration. We have before us some particulars of the boiler house of the West Penn Power Company at Springdale, Pennsylvania, which is equipped for burning pulverised coal on the Lopulco system. From the bottom of the basement to the inside of the flat roof, which only just clears the equipment, is a height of no less than 126 ft., while the boiler drums are 53 ft. 11 in. above the level of the furnace floor. Boiler houses like this are not built for nothing, and a very substantial increase in operating efficiency must be secured to warrant their expense.

AIRSHIP DEVELOPMENT.

THE advocates of the rigid airship will have experienced another disappointment with the appearance of the Air Estimates for the coming financial year and the omission from them of any provision for the encouragement and support of what is now known as the Burney Airship Scheme. It would appear from statements made in the House of Commons that the late Government had very carefully examined, and after some modifications were satisfied with, the general financial and other arrangements proposed by Commander Burney and his associates for the contemplated Empire Airship Service. The late Cabinet had arranged to include a sufficient sum in their proposed estimates for its inception, and all that remained was the covering approval of Parliament. Their successors in the administration propose to reconsider the whole matter, and have appointed a small committee of the Cabinet for this purpose. Some time will probably elapse before a decision is reached, and in the meantime the promoters of the scheme can take very few practical steps in the organisation of the service, until they are informed as to the attitude of the Government and the financial support they are prepared to offer.

If at some future time a writer attempts the history of airship development in this country, he will be forced at the outset to remark on the absence of any definite and continuous policy on the part of successive administrations. He will find that due to this, progress had been spasmodic and uncertain, and the experience gained at a time of relative activity had been almost completely thrown away in the inactive interval which followed. The complete and continued absence of any definite policy had not only been uneconomical, but disheartening in the highest degree to those who had interested themselves in the subject.

Such a state of affairs is perhaps one of the disadvantages of democratic government, a change in the political colour of the party in power being usually accompanied either by a complete reversal in policy, or by its lengthy reconsideration and modification, with consequent delays. In this particular instance the circumstances are generally different from those which usually obtain. The subject is highly technical, the new ministers bring no special knowledge to bear on the matter and must rely for information and guidance on the reports of the same technical officers who advised their predecessors. As we understand it, the promoters of the Burney scheme require a guaranteed subsidy from the Government, and unless this is forthcoming and is of sufficient amount, the service will not be proceeded with.

Whilst delay is being experienced in this country, progress is being effected in the United States, where an important step has been taken by which the value of rigid and other airships, from both the commercial and military points of view, has been very considerably augmented. Helium has been substituted for hydrogen as the gas for filling the gas-bags of rigid airships and the envelopes of those of other types. By this alteration the safety has been materially increased, for the hydrogen-filled airship, propelled by petrol engines and having necessarily long leads of pipes between the petrol tanks and the engines, was almost as dangerous as the proverbial light in a gunpowder magazine.

During the war the methods of attack which were developed against airships depended almost wholly for their success upon the ready inflammability of hydrogen, and with a gas, such as helium, which has not this disability new methods of attack must be devised and developed. Doubtless these will be forthcoming when the occasion arises, but at present it is difficult to predict the form they will take. It would appear that, with the danger of fire removed they will be less completely destructive in their effect than those which were used with such success against hydrogen-filled envelopes, and will for this reason give a far greater chance of escape to the crews.

It is interesting to reflect that helium was discovered and experimented with about thirty years ago by the eminent British chemist, Sir William Ramsay, and its adoption by the United States authorities for the filling of airship envelopes is the first and only practical use to which it has been applied. Helium is the next lightest known gas to hydrogen, and is remarkable as being the most inert of all the elements. It does not burn or support combustion; it has no taste, colour or smell; and, so far as is known, it does not enter into chemical combination with other elements. It is present in extremely small quantities in the atmosphere, and is found mechanically retained in many mineral earths which are radioactive in character, and particularly in thonanite, a mineral earth obtained from Ceylon. It is present in mineral springs and also in the natural gases which arise from wells in many parts of the United States and Canada. It is from this last source that the United States Government is obtaining the supplies for its airships. During the war it was frequently reported that the Germans were preparing to use it in their airships. Probably on account of the rarity of the sources of supply, the lack of knowledge as to its preparation on a large scale, and to the high cost of its production, it was never so used, a fortunate circumstance for the populations of the Allied towns which were within reach of the activities of the Zeppelin raiders.

The American authorities commenced their experiments on its production in large quantities early in 1917, and by the autumn of the following year had erected a plant for its extraction from natural gases containing about 1 per cent. helium. The plant was found capable of producing about 8,000 cubic ft. a day, at a cost of about fivepence a cubic foot, or roughly twenty times that of hydrogen. The process which was employed subjected the natural gas to compression, by which all the gases present, except helium, were liquefied. The helium passed over and was collected in suitable vessels. The process was in two stages, the helium obtained from the first stage having about 70 per cent. purity which in the second stage was increased to 92 or 93 per cent. It is now stated that either a new process has been devised, or the old method so improved that in a single stage helium of sufficient purity for use in airships can be obtained at a cost of about ten times that of hydrogen. It is expected that with further experience the relative cost will be reduced.

Although the use of helium in commercial airships is highly desirable, it is probable that, so far as this country is concerned, the high cost of production would at present render its use prohibitive. Since the gas is about 8 per cent. heavier than hydrogen, an airship filled with it must, for the same gross lift, have about 10 per cent. greater volume. Colonel Crocco, the distinguished Italian airship designer, has recently discussed the problem of the commercial airship and the effect on it of the use of helium. According to his calculations, an airship built and operated as at present, and engaged in flight for half its time, would require annually about twenty times its volume of helium. At this rate he considers only two airships, each of about 150 tons capacity, could be maintained with helium by the present American supply. He points out that by various modifications in the present construction, and also in the methods of navigation and working, very large economies in gas might be effected, and he estimates that the annual helium requirements would be reduced to 20 per cent. of the volume of the airship. This is a very considerable reduction and would render the use of helium a commercial possibility. He states that the cost of helium is now fifteen times that of hydrogen, a figure 50 per cent. greater than that quoted in the American press. Although the losses by diffusion are only about 50 per cent. those of hydrogen, Colonel Crocco suggests metallic coverings in place of fabric now used.

The United States are in the fortunate position of possessing the greatest "visible" supply of this remarkable gas, and the necessary plant for its extraction erected and in working order. They have also six years' practical experience with the gas, an advantage which no other nation possesses. It is probable the nations of Europe realising the value of helium for this special purpose, and with the example of the United States before them, will be ransacking their territories for the raw materials from which the gas can be obtained, and will proceed to investigate the most economical methods for its extraction and purification. So far as the British Empire is concerned natural gases containing helium are found in Canada, but the cost of collection and carriage of such gases to England and extraction of helium here, or alternately its extraction in Canada and carriage here, would be prohibitive for use in commercial airships. With the resources of such a wide-flung Empire it is to be hoped a more economical source will be discovered. Such a problem is worthy of consideration by the Council for Industrial and Scientific Research.

One other step would further increase the safety

of the airship, and that is the fitting of heavy oil engines for propulsion in place of those using petrol. Economy in weight is here the main object to be kept in view, and although it is understood experiments in this direction are proceeding, so far as can be ascertained a satisfactory solution has not yet been arrived at. If this type of engine can be designed sufficiently light to allow of its being installed in airships, and at the same time as reliable as the petrol engine, a new stage of airship development will have been reached the two dangerous factors, petrol and hydrogen, being no longer necessary parts of the equipment. But even with either of these factors omitted the safety of the airship will be increased beyond that with the present arrangements.

The promoters of the Burney airship scheme have not yet published the details of the airships which they are proposing to place on their Empire Service should they be fortunate enough to secure the necessary Government assistance. From interviews which Commander Burney has given press representatives it would appear various experiments and investigations have been proceeding, and all the latest and most up-to-date improvements will be embodied. For the reasons which have been referred to in the foregoing, it can hardly be expected that helium will find a place in those improvements, although it is to be hoped the developments in this direction have not been overlooked by the promoters. The heavy oil engine appears to be a more likely factor. So long, however, as hydrogen remains as the gas for inflation, the military value of such airships can hardly be rated at a very high figure.

It will be regrettable if such a scheme for airship development is reported upon unfavourably by the Cabinet Committee, unless at the same time an equally satisfactory alternative is propounded.

HORSE AND MOTOR HAULAGE.

FOR a good many years now mechanical engineers have lived in anticipation of the ultimate abolition of the horse on the roads. Whether the date be near or distant, faith in the profession has convinced them that in this mechanical age horse haulage must eventually give place to more advanced systems. To many the joy of such a triumph would be tempered, it must be admitted, with regret, for most of us inherit some of the old pleasure in the strength of a horse; such feelings have, however, to give way to considerations imposed by the conditions of modern life in large towns. There have, of course, always been enthusiasts before their time, and many have long glibly talked of the suppression of the horse. Little attention was in general paid to them, but in due course the war came, when the horse was taken from its peaceful work, its price doubled, and before normal conditions were reached again the country was flooded with re-conditioned motors, and a host of lorry drivers, equipped with an army training. People were on the verge of being convinced that the horse age was practically ended. Latterly costs have swung again. We are slowly recovering and some disillusionment is with us. The mechanical traction millenium has not yet arrived, and, while in military movements the mechanical arts are likely to be of ever-increasing importance, in more peaceful pursuits the horse will yet be found to have an economical field.

Whether its retention is desirable for secondary reasons, such as cleanliness of streets and the objection to the presence in towns of large stables, has nothing to do with the animal's capacity for doing work; if, judged by the latter, there are many to-day who have lost their love for mechanical traction with which they coquetted after the war, and have returned to the "hay-motor," or, as they sometimes say on the Continent, the "hippomobile."

It is often remarked that congested places, such as Covent Garden, Billingsgate, &c., show a surprising preponderance to this day, of heavy horse-drawn vehicles. The reason is not far to seek. Broadly speaking, the heavy traffic at a point like Covent Garden can be divided into bulk traffic from outlying market gardens, and that to and from docks and railways. The remainder consists practically of the vehicles of retailers, &c., from the suburbs. Of the two heavy classes quite a large proportion of the first class is efficiently done by motor vehicles. For the second horse haulage is still preferred, for which at least two good reasons can be advanced. The less important is indisputable and can be quickly dismissed. In narrow streets and confined areas, sometimes to be found in the neighbourhood of such markets as those to which we refer and often in the goods stations and warehouses of the railways, built before the days of the motor, the superior manœuvring power of the horse vehicle is a very valuable factor. Here the speed of the motor as a contributary cause to the elimination of congestion does not enter. Movement at the best is slow and well within the power of the horse, while the turning circle of the horse vehicle is such that, as the saying goes, it can make rings round the big motor lorry.

The more important reason, from the owner's point of view, has its root in quite another consideration. It is due to the bearing total annual cost has upon standing time. Just as in railway transport the actual time of movement of a wagon-load of freight is a very small part of the whole time occupied between two successive loadings, so, as every successful road transporter is aware, the actual time occupied in cartage is generally very low compared with the total time spent in road haulier's work. The special class of market traffic to which we have referred above is an extreme one. The distances are relatively short; the delays at the markets abnormally long. Under these circumstances the more costly motor cannot in these days compete unless for some reason prices in connection with horse haulage are very high. The superficially attractive idea that an idle motor is not all the time "eating its head off" is discounted by the much higher standing charges which have to be carried.

Other services in which the motor vehicle is handicapped are of the type requiring frequent short stops. In these the petrol machine is further handicapped by the temptation to keep the motor running while standing, but the electric vehicle here finds a useful field. The total stopping time, however, counts as before, and whether it be concentrated or dissipated in small amounts, it has a great influence on the distance which must be travelled before the two forms of haulage are on an equal footing.

This aspect was considered recently by Mr. E. Falconer in a paper read before the Graduates' Section of the Institute of Transport. Mr. Falconer included some very interesting costs in his paper, but his intention was rather to direct attention to general issues than to refer to particular records. With this object in view, and on the premises that records show that a suitable motor costs twice as much, all in, for the year, as a suitable cart and horse team, Mr. Falconer propounded certain formulæ intended to give a correct general idea of the relative economical merits of the two services. These were based on simple proportion, and, giving symbols to represent the two overall costs per annum, total standing time, minutes per mile for each form of haulage, tons and mileage essential to the operation, this proportion was arranged as follows:—cost of horse : cost of motor :: time occupied by motor per ton-mile : time occupied by horse per ton mile. From this the effect of variation of costs and the influence of standing times can be readily ascertained, while a slight modification makes it possible to take account of the capacity of the vehicles also. Mr. Falconer made use of this to point some morals. The costs used in working out the examples were 250*l.* per annum for a single horse team; 350*l.* per annum for a pair horse team; the same for a 1-ton petrol motor; 460*l.* for a 2-ton motor, and the same for a 3-ton motor. With these figures, and comparing a horse and 2-ton motor, carting 2 tons of traffic, with calls, it was shown that with loads involving six calls, the horse can compete with the motor up to 7 miles, assuming back loading, each additional 5 minute stop adding two-fifths of a mile to the economical equality of the horse and motor. For two such teams, carting to one destination, the two are on equality up to 5 miles, beyond which the motor has the advantage. Again working to one destination with a full load, a trotting horse can hold its own against a 1-ton motor up to 4 miles, but for the same conditions of full load to one consignee a 3-ton motor becomes as cheap as a pair horse team at 2 miles and over. If, compared with the trotting horse, it is only possible to employ a 2-ton motor for the 30-cwt. load, the horse has the advantage within the range of its powers.

In parcels work, taking the case of 1 ton of goods delivered to 80 consignees, the horse, within its physical capabilities, can work up to any distance more economically than the 1-ton motor. On heavier work, such as 2 tons of goods delivered to four consignees, the motor becomes economical at 6¼ miles and over, but additional delays increase the distance and an extra 30 minutes would raise the limit for the horse to 8½ miles.

These figures are not quoted that they may be used by our readers as absolute. They are given by Mr. Falconer merely to illustrate a point which he wished especially to bring out. That they well demonstrate the bearing which delays have on operation is unquestionable. In some forms of work the delays are controllable, as, for instance, when a road department does its own haulage. In practically every instance in which transport is sold, however, the haulier is at the mercy of his customer. Every road transport company is only too well aware of the delays involved in standing, waiting for loads "not quite ready." These have often actually meant the difference between profit and loss, though few probably have gone into the question so minutely as to realise the fact. It might be possible to introduce some discount system to the benefit of firms co-operating in the avoidance of such delays, but for much of the work on the roads it is to be feared that the motor haulier will have to put up with these vexatious losses or be content to relinquish the traffic to others.

DAMAGE TO CARGO; SEAWORTHINESS.

THE question whether a ship is seaworthy in the ordinary sense is usually one of fact, but the case of the s.s. Grelwen, decided by the House of Lords on March 18, shows that it may occasionally be a fine legal question whether a ship is to be regarded as seaworthy in the sense of being properly equipped for a particular charter or for the carriage of a particular cargo. Of the nine judges who heard the case, in different courts, four—Rowlatt, J. Bankes, L. J.; Eve, J. and Lord Finlay—held that the Grelwen was not seaworthy in this sense, and five, Scrutton, L. J.; and Lords Cave, Dunedin, Sumner and Carson—held that she was. The facts were as follows:—Messrs. Elder Dempster and Company, to make good a temporary deficiency in the fleet for their West African trade, chartered a vessel from another company. The vessel, which had deep holds but no 'tween decks, went to the Sherbro River in West Africa and loaded about 300 casks of palm oil, which were stowed in tiers at the bottom of the holds, and about 50,000 bags of palm kernels, which were stowed partly over the casks of oil. When the vessel arrived at Hull it was found that the casks of oil had been crushed by the weight of the palm kernels stored above them. The casks must have begun to give way as soon as the palm kernels were stowed above them, for there was about 3 ft. of palm oil in one of the holds before the vessel left the Sherbro River. The shippers of the cargo claimed damages against the charterers for breach of the contract entered into by the bills of lading. The charterers were apparently protected against liability for damage due to bad stowage, but not against damage due to unseaworthiness; and the question was whether the damage was due to bad stowage or to the vessel being structurally unfit or unseaworthy for the carriage of the palm oil by reason of the depth of the holds and the absence of 'tween decks.

Mr. Justice Rowlatt held that the vessel, in the way in which it was prepared for the voyage, was not proper to carry the casks of palm oil. This decision was affirmed by a majority of the Court of Appeal, Lord Justice Scrutton dissenting; but the House of Lords, by a majority of four to one, held that the ship was seaworthy and the damage was due to bad stowage.

Lord Cave said it was well settled that a ship owner

or charterer who contracted to carry goods by sea warranted that the ship should be seaworthy, *i.e.*, should be tight, staunch and strong, &c., and should be reasonably fit for receiving cargo and carrying it across the sea, but there was no rule that if two parcels of cargo were so stowed that one could injure the other during the course of the voyage, the ship was unseaworthy. He came to the conclusion, therefore, that the damage complained of was due not to unseaworthiness but to improper stowage. When the palm oil was loaded the vessel was unquestionably fit to receive and carry it. The damage was due to the fact that after the casks of oil had been stowed in the holds the master placed on them a weight which no casks could be expected to bear. If he could not have stowed all the palm kernels without injuring the casks of oil, he could have refused to accept some part of the kernels and the oil would then have travelled safely, although no doubt that might have rendered the voyage unprofitable. The important thing was that when the oil was loaded the ship was fit to receive and carry it without injury. Lords Dunedin, Sumner and Carson agreed. Lord Finlay differed, and said that in the West African trade it was usual to carry both palm oil and palm kernels and that ships regularly engaged in the trade had a 'tween deck. A 'tween deck was necessary where palm oil and palm kernels had to be carried, in order that a full cargo could be carried. Without a 'tween deck there was always the risk of the person superintending the loading making a mistake as to how much weight the casks of palm oil could bear on the top. In his view, a vessel which could not carry a composite cargo such as was usual in the West African trade, without the risk of the lower part of the cargo being crushed by the upper, because of the absence of 'tween decks, was not suitable and was unseaworthy in being improperly equipped for the service.

THE LATE DR. R. E. FROUDE.

DR. ROBERT EDMUND FROUDE, the son of a brilliant father, the late Mr. William Froude, and his assistant and successor in the work with ship models in experimental tanks, from which most valuable results were derived, died at Croft Cottage, Cambridge, in his seventy-eighth year, on Wednesday, March 19.

Half a century ago his father constructed a tank at Chelston Cross, Torquay, to ascertain from models the power necessary to drive any specific form of vessel at a predetermined speed. By means of changes in the models the effects on the power required were observed, and so by gradual processes and exacting test work the best lines for a vessel were obtained. To-day such matters seem commonplace, as all vessels are designed from information obtained in tank tests, but it must not be forgotten that there was a time, at the start of this work, when its value did not appeal to all—as it now does. In this work Mr. R. E. Froude joined his father at the age of 25, and remained with him as assistant until his death in 1879. Then the son was appointed superintendent of the work, which had been taken over by the Admiralty. The tank at Haslar, Gosport, was not finished in time to be used by Mr. William Froude, but it was there that Mr. R. E. Froude performed his valuable experimental work. The results of this work were embodied in papers which he gave to the various institutions, but principally to the Institution of Naval Architects, of which he was elected an Associate in 1880 and a Member of Council three years later. To refer to the individual papers would take up great space, for they were numerous. He investigated wave-making resistances, screw-propeller efficiencies and dimensions, the rolling of ships, the differing effects of moving in still water and through artificially produced waves, and provided a wealth of information of the greatest value to the ship designer. This method of investigation of ship-construction problems has taken a complete hold of naval architects, and many private firms—such as Messrs. W. Denny and Bros., of Dumbarton, Messrs. John Brown and Co., of Clydebank, and Messrs. Vickers, Limited, at St. Albans—established tanks of their own. The William Froude National Tank at Teddington was presented to the nation by Sir Alfred Yarrow, who has had the satisfaction of seeing the value of his gift in the improvement of naval architecture which has been effected through the results obtained in work with it. From the small beginnings of the older Froude's endeavours, continued by his gifted son, there has thus been established many tanks in this country, as well as a number abroad. There can be no doubt that much of the exceptional efficiency of British ship design is due in large measure to the experimental work which he conducted. His work on screw-propeller design and efficiency remains as a lasting memorial to a most exceptionally painstaking and thorough experimental investigator. He resigned from active work in 1919. The younger Froude, like his father, was elected a Fellow of the Royal Society, but also held the LL.D. degree of Glasgow University. He was elected a Vice-President of the Institution of Naval Architects in 1905 and was gazetted C.B. in 1911.

Those who were associated with Mr. R. E. Froude will always remember him as a man of reserved character but of most charming personality, whose contribution to discussions on problems of ship design were appreciated by all. In discussion he was ever courteous but firm in the expression of his opinions, which, being backed by a wealth of experience and the deductions of a thoroughly trained scientific mind and delivered by a man who had a most charming and convincing way of addressing an audience, never failed to make a lasting impression.

THE TRAM STRIKE AND METROPOLITAN TRAFFIC.

THE strike of the tramway and motor 'bus drivers in the metropolitan area has brought the subject of traffic into great prominence, and the Government have introduced a Bill to set up a new authority for the regulation of traffic within a radius of 25 miles of London. A Board of Inquiry was set up to ascertain the strike situation from the financial point of view, and the conclusion they arrived at was that the tramway and 'bus systems could not meet the increased wage demanded by the worker out of existing revenue. This, in itself creates a serious condition. It was, moreover, proved that there was excessive competition, and it becomes therefore of considerable interest to review the whole situation of metropolitan traffic.

According to a Board of Trade report published early in 1914, the motor-bus of that date competed in speed with the tubes up to a distance of 2 miles. Of course, actual maximum speeds were much less than below ground, but the "terminal" delays were so much smaller with the 'bus that the tubes had, on the average, no advantage up to the limit stated. From figures given in the same report it appears that in 1911 licenses were held by 2,748 motor-buses. This figure has now been very substantially increased and the London General Omnibus Company had 3,869 'buses in operation last December and were increasing this number at the rate of 25 per week. Other companies ran 208 buses making a total of somewhere over 4,000. The gain in numbers is smaller than might perhaps have been expected, but it must be remembered that the modern motor-bus is both larger and more reliable than its predecessor. In any case the greater number now at work adds very materially to the frequency of the services, and it is this which is often the determining factor as to whether a 'bus does or does not secure a passenger. This is very obvious in certain parts of the London area where 'buses and trams are running in competition, but where the latter are giving the more frequent service. If the 'bus chances to arrive at a starting point at the same time as the tramcar, it secures most of the passengers, since, owing to the facility with which it can wend its way through traffic, its trip time between competing points is less than that of the tramcar, although the latter has the higher maximum speed. The difference in the speed of transit, however, is not sufficient to induce passengers to wait for a 'bus if a tramcar is immediately available, since on the average a net saving of time is effected by taking the first vehicle to hand. Hence, although average 'bus speeds in the busier parts of the metropolis may be less than they were 10 years ago, as Lord Ashfield declares, it does not necessarily follow that the average time a passenger spends in getting from door to door is greater under the conditions of to-day. The more frequent service must reduce the terminal delays, and it is these which are the principal handicap to the tubes in their competition with their rivals on the roadways.

That the above view is substantially correct seems indicated by the extraordinary growth of the 'bus traffic. In 1911 the buses carried 401 million passengers, and the electric railways 436 million. Last year the motor-buses carried 1,214 million passengers. The tramways, including all services, carried 1,050 million so that the more modern vehicle has definitely outstripped its rival, and provided nothing is done by Parliament to hinder enterprise, the advantage now held may be expected to increase with each successive year.

A noteworthy feature of the motor-bus undertaking is the very high working ratio. The receipts of the London General Omnibus Company last year amounted to 7,655,413*l.*, whilst the expenditure was 7,145,582*l.* This corresponds to an expenses ratio of about 93½ per cent. of receipts. A railway with a similar ratio would be in a decidedly parlous state, as a reduction of 6 per cent. in its net receipts would extinguish all profit. The motor-bus has, however, two very great advantages. In the first place, its fixed charges are very low. The total capital expenditure involved in the transport of the 1,200 million passengers afore-mentioned is only some 5½ to 6 millions sterling. Others are desirous of securing a share of this highly remunerative traffic, and in fact there are 74 other companies, with 208 buses, already at work in the Metropolis. It has to be borne in mind, however, that the margin of income over expenditure is small, and in pre-war times none of the big railway companies were able to run their motor-bus services at any reasonable profit. In fact, in most cases there was an actual loss on each year's working.

The second advantage that the motor-bus possesses is its flexibility. If any particular route proves unprofitable, another may be sought. Fares also are not subject to legal control, and it must be admitted that the absence of this has not in any way proved detrimental to the public. As the history of our mercantile marine during the last century proved, large profits are soon translated into better services and improved equipment, and if doctrinaire politicians will withhold their legislative hand history may be expected to repeat itself in this regard.

The capital expenditure on the railways of the Underground Group has been about 62,250,000*l.*, and they carried during the year 255 million passengers, exclusive of season ticket holders. With the aid of the Treasury guarantee, 11 miles of extensions are now in progress, and these will tap new areas and cause a further influx of traffic to the streets. The growth of the travelling habit is indeed remarkable. In 1911 the Board of Trade estimated that, exclusive of main line suburban traffic, every person in the Greater London area made on the average 145 journeys in 1903, the population being then 6,710,000. In 1911 the figure had risen to 229 journeys per head, the population having grown to 7,250,000. In 1913 Lord Ashfield states that the journeys per head numbered 305, but perhaps this includes main line suburban services. In 1923 this figure had increased to 414 per head, although the City and South London line was closed for the whole of the year.

Year by year the tendency is for the population to spread farther afield, and the best hope for the tubes and underground railways generally is to tap this additional traffic. The introduction of escalators is a valuable aid, but it is impossible to reduce the "terminal" delays to 'bus proportions in the competition for short-distance traffic. This is evidently recognised by the Metropolitan Railway Company, which, rather than relying on expansion of traffic in the Metropolis, has adopted the policy of developing the residential districts beyond Harrow, and is extending the electrification of its line from Rickmansworth to Harrow, and is also proposing to

work electrically the branch to Watford now under construction.

Similar work is contemplated by the Southern Railway Company, who propose during the present year to extend the electrification of the line to Sutton, and may thence go on to Epsom. On the South Western branch the electrified sections are to be extended to Guildford, Effingham Junction, and Dorking. This will nearly complete the electrification of the South Western suburban area, and the prospective advantages may be gauged from the fact that the existing electrified services carried last year 26 million more passengers than the former steam trains. The passenger traffic over the Brighton electrified system is very nearly twice as great as it was with steam. It is intended to proceed with the electrification of the whole of the South Eastern and Chatham suburban area. This will make Charing Cross station of very great importance to the South Eastern suburban districts.

The spread of the population further out has some very great advantages, but it leads to the construction of square miles of small houses instead of more imposing blocks of flats and tenements. The gain to health is, however, very marked, and it is of interest to note that pre-war statistics showed that deaths from tuberculosis were 50 per cent. lower in our acres of mean streets than in Berlin, where architectural effects had been aimed at, in conjunction with a carefully studied scheme of town-planning. The result of this procedure was that the number of residents per house averaged 77 in Berlin, as against 8 in the London area, and 32,000 people were crammed into 1 sq. km., as against 13,000 in the corresponding London area. On the other hand, it must be admitted that the city worker who elects to live far afield gives certain hostages to fortune, in laying himself open to serious inconvenience from "lightning" or deliberate strikes of transport workers.

The question of bridges has been much discussed, and it would seem from the statistics available that congestion is much worse on the bridges serving the City than it is further west. There is not a great deal of difference in the number of vehicles crossing Westminster, Blackfriars and London Bridges. Westminster Bridge is, however, 58½ ft. wide, Blackfriars 73 ft. wide, whilst London Bridge, as widened, is only 37 ft. wide, the Tower Bridge being 35 ft. wide. The class of vehicle crossing the Tower Bridge and London Bridge is, moreover, largely made up of trade vehicles of one kind and another, whilst this class of traffic, which has a high coefficient of obstructions, makes relatively little use of Westminster Bridge. On the other hand, both Westminster and Blackfriars Bridges have to accommodate the trams, which by direct and indirect effect obstruct the roadway more than any other type of vehicle. The above comparison of the relative congestion of the bridges is based on figures published in 1915, and may require some correction owing to changes effected during the intervening years.

NOTES.

PROPOSED ELECTRIFICATION OF THE GLASGOW SUBWAY.

AT the time when the City and South London Railway was under construction the Glasgow Subway Railway was being built. An entirely different attitude was shown, however, in dealing with the question of equipment, for in the Glasgow case use was made of an endless wire rope for propulsion. The trains were run in two separate circular tracks and no cross-over roads and no sidings were provided. All the trains were kept on the running lines night and day, except for the periods when they were raised by a crane into the workshops for inspection and repair. As all the trains were run during the whole working day without any possible change at rush hours, the system of operation proved most wasteful, and the company passed through very difficult times. The Glasgow Corporation has now purchased the undertaking and hopes to electrify it and, at the same time, make such modifications as may be necessary to ensure that the system can be extended to meet the growing needs of a large city. As a preliminary to electrification. investigations have been conducted by Mr. W. C. Easton, as consulting engineer to the undertaking, who has reported that sidings are necessary, both to ensure the means of parking the trains during slack hours and also as a provision to make possible daily inspection of the running equipment. Another suggested piece of work to be done immediately is the provision of cross-over roads to facilitate the working. When this work has been done electrification will be undertaken and later the stations will be extended, and improved facilities provided for the conveyance of passengers between the street level and the tube, at any rate, at some of the deeper stations. It is proposed to purchase the components of the equipment and to assemble the rolling-stock by the use of labour available at the tramway works. The gauge is at present 4 ft., but the necessity for its extension is not so great as with other tube systems, where there is possibility of running out of the tube on to standard gauge railways. This question of gauge has, however, not yet been settled, Active work is being done at present in cementing the walls and improving the pumping equipment. A great increase in speed of running is in contemplation for the electrified tube.

BALANCING PRODUCTS OF COAL CARBONISATION.

In Dr. Lander's paper on the "Work of the Fuel Research Board," read at Leeds, before the Midland Institute of Mining Engineers, and the critical, though sympathetic, discussion to which it gave rise, the author drew attention once again to the importance of balancing the products of coal carbonisation, so that an increase in the make of one product should not be accompanied by a surplus of another. The economical need for such a balance becomes more strikingly evident as progress is made in processes such as high-temperature carbonisation in vertical retorts. The natural outlet of such processes, with their huge increase in the yield of gas, is the substitution of gas for solid fuel in domestic grates. The extent to which this outlet is likely to become available is doubtless limited by an old-established prejudice in favour of the grate with solid fuel, and a wide-felt reluctance to dispense with either its cheerful comfort or its convenience as a miniature destructor. But, apart from this sentiment, which will certainly operate to limit the extent to which domestic gasheating will become general in this country, matters must be so arranged that a large increase in the volume of gas made must not be accompanied by a nearly proportionate increase in the production of coke. Otherwise, from an economical point of view, either fresh uses would have to be found for the coke, or it would become a depreciated product, for much of which it would be hard to find a use at any price. Similarly, if it were sought to produce fuel oil on a large scale from coke ovens, an enormous quantity of unsaleable gas would be produced, and a large part of the metallurgical coke might, as Dr. Lander observed, become for the time being a drug on the market. The difficulty of obtaining the economic balance in the products of carbonising coal lies, indeed, largely in the vast scale on which a successful process would be likely to be worked, which might itself produce a serious depression in the market prices of one or more of the products. From this point of view, most is perhaps to be hoped from some low-temperature process, if the solid product were acceptable for general use. On published results there seems to be hope that such a process may be elaborated, though nothing conclusive has yet been demonstrated, and the hope is the more substantial because, in more than one quarter, work is progressing on the subject with the apparent determination to attempt no wide introduction of the process until it has been tried out thoroughly, not only on an experimental but on a works scale.

A TRADE UNION LITIGATION.

Several interesting legal questions were raised in the case of Holland against the London Society of Compositors, in which Mr. Justice Lush gave judgment on March 13. Apparently there had been an agreement between a provincial trade union, the Typographical Association, and the London Society of Compositors, in which the two unions agreed not to compete with each other in the same area, the district within a radius of 15 miles of Charing Cross being allocated to the London Society, and the provinces to the Typographical Association. A member of the Association coming to London was to be entitled, on production of a clean ticket from the Association, to a card of admission from the London Society. There was a corresponding arrangement for men going from London to the provinces. The plaintiff was a member of the Typographical Association and had come to London. He alleged that he had been refused a card by the Secretary of the London Society, and as a result had been unable to take up a job which was available for him. He pleaded that the agreement between the two unions had been made for his benefit and he was entitled to have it enforced; and he claimed an injunction to restrain the London Society from excluding him from membership, and damages. The defendants, in addition to denying that the plaintiff was entitled to a card, pleaded that he was not a party to the agreement and therefore had no cause of action, and that in any event the agreement was an agreement made by one trade union with another and could not be enforced by the courts, as the defendant Society was an illegal Association at common law. Mr. Justice Lush held that the action was not maintainable, as the plaintiff was not a party to the agreement. In his view the agreement had been made by the trade unions for their own purposes and not for the benefit of individuals. The action therefore failed. Employers are, perhaps, not often directly concerned with the enforcement of agreements between one trade union of workpeople and another; but the judgment applies equally to agreements between a trade union of workers and a trade union, or association, of employers. Unless the agreement is made for the benefit of individual members of the respective associations, individuals should not attempt to enforce them in the law courts; and even where such agreements can be regarded as made for the benefit of individuals, anyone seeking to have them enforced by the courts may be met with the difficulty that the courts will not entertain actions for the direct enforcement of agreements between one trade union and another where one of the parties is an illegal association at common law—*i.e.*, where its objects are in restraint of trade.

INSTITUTION OF NAVAL ARCHITECTS.

A varied programme has been arranged for the annual session of the Institution of Naval Architects, which begins on April 9. Following upon the presidential address there will be, in accordance with the almost invariable tradition, a discussion by naval officers—this year on a paper to be submitted by Admiral of the Fleet Sir Doveton Sturdee, who will deal with the "Strategical and Tactical Considerations Governing Warship Design." This discussion should be of importance in view of the limitation in the size of battleships and the tendency, especially in foreign countries, to build a large fleet of 10,000-ton light cruisers. The morning meeting of Thursday will concern itself largely with transport. Mr. Archibald Hurd will lead off with a paper on "The Future of Sea Transport." He will be followed by Commander C. D. Burney, who has done so much in connection with airship development, and will confine his paper to transport by this new medium. The third paper is on "Seaborne Coastal Trade," by Sir Alfred Read. In the afternoon, tank experiments will fall to be considered, one of the papers dealing with rolling experiments and the other with the drifting of ships caused by rolling among waves. The latter is by Professor Suyehiro and the former by Mr. M. P. Payne. The evening meeting on Thursday will be given up largely to engineering questions. The principal paper down for consideration is by Mr. R. W. Allen, of Bedford, and is on the "Application of Steam Turbines to Auxiliary Machinery," a contribution with regard to which his experience justifies high expectations. There will also be a paper on "High Elastic Limit Mild Steel and its General Applications." The opening paper on Friday will deal with experimental work on Diesel engines at the Admiralty Experimental Factory, the contribution being made by a member

of the staff, Engineer-Commander R. Beeman. The vibrations of ships and the torsion of shafts will form the subject of other papers for Friday morning's meeting. At the afternoon meeting, Mr. J. L. Kent, of the National Physical Laboratory, will deal with the "Effect of Wind and Waves on the Propulsion of Ships." The other subjects for consideration at this concluding meeting will deal mostly with experimental research on skin friction and resistance. The Institution is to have a Summer Meeting in London, beginning on June 25 next, when it is the intention to hold meetings for the discussion of papers on two forenoons only, namely, Wednesday, the 25th, and Friday, the 27th. The remainder of the week will be devoted to social functions. On Monday, June 30, and Tuesday, July 1, it is proposed to visit Glasgow and the Clyde District. On Wednesday, July 2, a visit will be paid to Newcastle and the Tyne District, the members and their friends returning to London on July 3.

THE JUBILEE OF THE PHYSICAL SOCIETY OF LONDON.

The Jubilee celebration of the Physical Society, to which we referred on page 364 of last week's issue, was carried through with much success. The exhibition illustrating the work of the Society attracted many visitors on the three afternoons of the celebration, Thursday, Friday and Saturday last week. On the Thursday, the president, Mr. F. E. Smith, F.R.S., to whose scientific work and activity in the interests of the Society many an allusion was made, received the foreign, Dominion and home delegates, who were introduced by the senior secretary, Professor A. O. Rankine. There were representatives of the physical societies of America, France, Germany, Japan, Russia and Switzerland, of the Royal Academies of Amsterdam, Brussels, Madrid and Rome, of the Carnegie Institute and Bureau of Standards, Washington, of the Royal Societies of Dublin, Canada and Victoria, and of the leading scientific and technical institutions of this country. The Duc de Broglie then delivered the Guthrie lecture on "The Photo-electric Effect in the Case of High Frequency Radiation and Some Associated Phenomena," giving a very instructive account of secondary radiation phenomena from the electrone and quantum standpoints and of the difficulties caused, notably by the recent experiment of Compton, which we mentioned in connection with Sir William Bragg's recent discourse on crystal structure.* Sir Richard Paget's discourse on "The Nature of Speech," which followed, was really delivered before the hosts of the Society on this occasion, the Institution of Electrical Engineers. On Friday afternoon a large audience listened for four hours to reminiscences of original members and past presidents of the Society. Sir W. Barrett, Dr. J. A. Fleming, Sir Arthur Schuster, Dr. C. Chree, and Professor H. E. Armstrong; Sir Richard Glazebrook and Sir Oliver Lodge joined to their reminiscences discourses on "Electrical Measurements" and on "Our Present Position regarding the Ether." To the young men present names like Guthrie, Gladstone, Fitzgerald, William Thomson, Stokes, Poynting were merely names connected with great work and discoveries; but many Fellows present were deeply stirred by being taken back once more to the persons by whom, and to the time when, physical laboratories had to be created. It is impossible to epitomise the interesting addresses and the many speeches delivered at the final banquet, on the Saturday evening. Mr. Ramsay MacDonald, proposing the Physical Society, asked whether we could ever simplify things again and produce scientific methods to regulate our conduct, and Lord Haldane emphasised that clear conceptions were essential. Some of the learned speakers forgot the importance of the time factor, in spite of the good example set by the Duke of York.

AMERICAN HIGH-SPEED STEEL.—A high-production cutting metal known as "Jolite," the base of which is high-speed steel, has been placed on the market by the Jolite Tool Company, Milwaukee, says *The Iron Age* New York. The process of manufacture of the metal is claimed to be one that can be duplicated with precision; the process hardens the steel throughout, and further treatment by the user is not only unnecessary, but re-treating is said to nullify the process.

* See ENGINEERING, February 8, page 163.

LITERATURE.

Acoustics of Buildings, including Acoustics of Auditoriums and Sound-Proofing of Rooms. By F. R. WATSON, Professor of Experimental Physics, Urbana, Illinois, U.S.A. New York: John Wiley and Sons. London: Chapman and Hall. 1923. [Price 15*s.* net.]

THE claims of æsthetics have frequently so dominated the work of the architect that, as a rule, more attention is given to the production of an imposing and pleasing exterior than to the designing of an auditorium possessing adequate acoustical qualities. It may be said with some confidence that till the late Prof. Sabine, of Harvard, began his experiments, towards the close of the last century, architects neither knew what was required, nor how to produce any desired result. He trained experimenters who, by accurate observation, founded on rigorous theory, have given numerical values to the factors depending on the variables entering the problem, with the happy result that the character and quality of the acoustics of any building can be pre-determined within limits. It had long been thought sufficient to design the interior of a hall or theatre on lines that, adopted in some similar building, had given satisfactory results, and great was the disappointment, and grievous the puzzle to explain the causes, of the observed differences. Of course, no two buildings do accurately correspond, the dimensions may be proportioned with fair correctness, but the materials of construction, the ornamentation, ventilation, lighting will be changed, and these alterations will affect the result. Indeed, if the proportions and details were accurately copied, the very difference in size would alter the acoustics markedly in some respects.

Prof. Watson's purpose is to explain the causes of these variations, and to explain to architects and engineers the principles, whose observance will ensure the attainment of any desired quality in the completed building. His contribution to the literature of the subject is the more welcome because he insists on the necessity of following established theory, and enforces his views by references to examples that are both interesting and pertinent. He explains and demonstrates the physical conditions on which audition, resonance, reverberation, echoes, and allied phenomena depend, and shows the construction or arrangement to adopt in order that speech or music may be heard most effectively.

The expedients adopted in the past and up to very recent times to remedy faulty auditoriums show how little has been scientifically known, and the necessity for inculcating sounder principles. In the future we cannot doubt but that more consideration will be given to the part played by reflection, absorption and transmission in the propagation of sound, so that suitable intensity will prevail in every part of a hall or building, without echoes or distortion of the original sound, each articulation dying out quickly enough to avoid interference with succeeding sounds. Incidentally, it may be mentioned, that the blending and prolongation of notes in music may be of advantage in concert halls, but the mixing of words in speech is always objectionable, so that it is impossible to satisfy perfectly the requirements of both speech and music in the same auditorium. Some compromise must be permitted.

The causes of resonance, interference and echoes are considered very practically, and though the explanation of their effects seems simple when the mechanism and behaviour of a sound wave is understood, it was the failure to master the elementary principles that led to the adoption of such childish remedies as the stretching of wires throughout an auditorium to correct faulty acoustics. Wires cannot have any effect since they present too small a surface to disturb the waves. Their effect on sound may be compared to that which a fish line in water produces on water waves. Similarly, the sounding boards to be seen over the pulpits in many churches are a quite insufficient correction for a reverberant auditorium. If such a device effects an improvement in certain cases, it must be a fortuitous coincidence, for it is impossible to prescribe a general remedy when the defect is the product of varied and conflicting conditions.

Architects have had the advantage of one feature that has worked consistently in their favour, the presence of an audience, for in a majority of cases a crowded house is its own corrective. The important point, however, to notice is that sufficient is known of the effects of sound absorptions by various materials, that the acoustics of a room of practically any dimensions is not a matter of guesswork. Mathematical formulæ exist which, if applied intelligently, will give the best acoustics in any auditorium, when the shape and time of reverberation have been determined. To illustrate this advance, Prof. Watson works out a number of instances, to show the possibility of defining the acoustic properties of an audience hall before construction, and to supply the necessary corrections for remedying pronounced defects in a completed building. The agreement found between prediction and observation in the first type is remarkably close and satisfactory. The advantages to the architect in being able to determine beforehand the construction and the materials to be used are manifest, and the knowledge proves economical. Where finished buildings have partially to be reconstructed the results are not so good, and the expenses usually heavy. A very instructive case is that of the auditorium of the University of Illinois, which was found to be acoustically faulty. The curved walls could not be straightened without doing violence to the architectural design, and the curvature gave rise to pronounced echoes, while at the same time the room was reverberant. Six years and a vast amount of money were spent to effect improvements. Less time might have been occupied, but it was determined to attack the problem systematically, and to make each experiment depend on scientific enquiries conducted in the laboratory. What is called the "diagnosis of the acoustical trouble" was pursued methodically and ingeniously. The location of the echoes was effected by reflecting the sound of the ticking of a watch from apparatus attached to the walls, suspected of originating the echoes. The reinforcement of the sound of ticking indicated the position of the echo. A metronome was tried in the same way, but the most sensitive means of detection proved to be an arc light placed in the focus of a parabolic reflector. A hissing sound was emitted from the light, and the path of the sound was easily noted by the position of the spot of light on the wall. The suggestions derived in this way pointed to a remodelling, which effected a marked improvement in the acoustic properties. A speaker could generally be heard, and music was more pleasant than under the previous conditions. The echoes due to the curved walls were very noticeable on particular occasions. This is a small reward for six years' work. The lesson to be learnt is to avoid curved walls in audience halls of any size. The curvature acts as a reflector, giving rise to regions of undue intensification and of comparative silence.

Another acoustical problem which comes before the architect and the physicist is the need for sound-proofing, or isolation. Hospitals, hotels, offices all at times require the suppression of noise, and the problem is found to be quite as difficult as that of producing uniform distribution. Sounds in air may be set up by a violin, and proceed outwards from the source by various routes, till they affect the room to be made sound-proof, or vibrations may be generated in the building and travel through the continuity of solid material. These latter are more difficult to suppress than those travelling through the air. The effective remedy consists in the interposition of a discontinuity in the path of the waves. Air spaces in masonry are partially effective, and an approximate solution is obtained by inserting air-filled materials such as hair-felt, incoherent sand, &c., which make a fairly complete break in the continuity of structure. The author gives some experimental tests on sound-proofing and examples of rooms and buildings that have been specially constructed to deaden sound, but evidently more experiments are needed. One great cause of failure and disappointment arises from the presence of a ventilating system, and unless the system can be eliminated or varied it seems useless to proceed with the work of isolation. With special forms of ventilating shafts it seems possible to secure immunity from disturbing sounds, provided the building is made rigid and massive to reduce vibration. The walls, floors and ceilings should be made continuous

and sufficiently rigid to prevent transmission of sound.

The book offers another instance of the application of physical and experimental science to the conduct of affairs, and in congratulating the author on the manner in which he has presented his facts, we may express the hope that those most interested in the discussion of the problem will benefit by its contents.

BOOKS RECEIVED.

Air Ministry. Air Publication No. 79. *Handbook on the L.B. Type, Aero Camera.* London: His Majesty's Stationery Office. [Price 3*s.* 6*d.* net.]

The Number System of Arithmetic and Algebra. By D. K. PICKER, M.A. Melbourne: University Press.

The Manufacture of Electric Steel. By FRANK T. SISCO. First edition. London: Mc.Graw-Hill Publishing Company, Limited.

Board of Education. Catalogue of the Collections in the Science Museum, South Kensington, with Descriptive and Historical Notes and Illustrations. Water Transport. I. Sailing Ships. Compiled by G. L. OVERTON, A.R.C.S. London: His Majesty's Stationery Office. [Price 1*s.* 6*d.* net.]

Précis de Chimie Physique. By H. VIGNERON. Paris: Masson et Cie. [Price 30 francs net.]

United States Department of Commerce. Simplified Practice Recommendation No. 4. *Asphalt.* [Price 5 cents.] No. 9, *Woven-wire Fencing.* [Price 5 cents.]. Issued by the Bureau of Standards. Washington Government Printing Office.

United States Bureau of Standards. Circular No. 56, *Standards for Electric Service.* Second edition. [Price 60 cents.] Scientific Papers. No. 477. *Spectro-radiometric Analysis of Radio Signals.* By CHESTER SNOW. [Price 10 cents.] Technologic Papers No. 241. *A Comparison of the Deoxidation Effects of Titanium and Silicon on the Properties of Rail Steel.* By G. K. BURGESS and C. W. QUICK. [Price 10 cents.] No. 243, *Stresses in a few Welded and Riveted Tanks Tested under Hydrostatic Pressure.* By A. H. STANG and T. W. GREENE. [Price 5 cents.] Washington: Government Printing Office.

United States Bureau of Mines. Thirteenth Annual Report by the Director of the Bureau of Mines to the Secretary of the Interior for the Fiscal Year ended June 30, 1923. [Price 5 cents.] *Self-contained Mine Rescue Oxygen Breathing Apparatus. A Handbook for Miners.* By D. J. PARKER AND OTHERS. [Price 20 cents.] Technical Paper No. 262. *Certain Interfacial Tension Equilibria Important in Flotation.* By W. H. COGHILL and C. O. ANDERSON. [Price 10 cents.] No. 274. *Efficiencies in the Use of Bituminous Coking Coal as Water-gas Generator Fuel.* By W. W. ODELL. [Price 10 cents.] No. 289, *Change Houses in the Lake Superior Region.* By C. E. Kindall. [Price 15 cents.] No. 319. *Methods of Decreasing Evaporation Losses of Petroleum.* By J. H. WIGGINS. [Price 15 cents.] Washington: Government Printing Office.

The Una-Flow Steam-engine. By Professor Dr. Ing. h.c. J. STUMPF. Translated by the Stumpf. Una-Flow Engine Company, Inc. London: Constable and Co., Limited. [Price 20*s.* net.]

Aeronautical Research Committee. Reports and Memoranda. No. 810, *The Accuracy of Sextant Observations taken from Aircraft.* By B. MELVILL JONES, M.A. A.F.C. [Price 1*s.* net.] No. 829, *Experiments with a Family of Airscrews, including the Effect of Tractor and Pusher Bodies. Part I. Experiments with the Family of Airscrews Mounted in Front of a Small Body.* By A. FAGE and OTHERS. [Price 3*s.* 6*d.* net.] London: His Majesty's Stationery Office.

The Elements of Automatic Telephony. By ARTHUR CROUCH. New York: Spon and Chamberlain. London: E. and F. N. Spon, Limited. [Price 3*s.* 6*d.* net.]

"EMPIRE COMMUNICATIONS."—After the business of the 6th annual general meeting of the Institution of Aeronautical Engineers, held on Monday last at the Engineers' Club, had been disposed of a paper bearing the above title was read by Mr. A. H. Ashbolt, Agent General for Tasmania. Mr. Ashbolt's paper dealt with the use of airships for communication between this country and the Overseas Dominions, and the author first expressed regret at the manner in which airship development had been neglected in this country for the last two or three years. He pointed out the importance of rapid communications in connection with trade expansion, mentioning that the time occupied in a journey between this country and Australia or New Zealand was now no less than was the case some thirty years ago. Airships afforded the best means of communication over long distances and were the only craft at present capable of sustained voyages at speeds greatly exceeding those of steamships. With regard to the safety and commercial prospects of airships, the author pointed out that the losses of the R.38 and the Dixmude were due to structural weakness, which could be remedied in commercial designs, and he also referred to the importance of the mooring mast, designed by Major Scott, in connection with commercial airship developments. Referring to the Burney airship scheme, in conclusion, the author urged upon the Government the necessity for coming to a prompt decision in the matter, remarking that Empire trade must be developed quickly. Airships, he said, would be an important factor in that development and at the same time they would increase the strength of the Navy and also diminish its cost.

THE LATE MR. HENRY DEANE.

WE regret to have to record the death, at the age of 77, of Mr. Henry Deane, who was long well known as the engineer-in-chief of the New South Wales Railways, and who, on the Commonwealth Government of Australia becoming directly interested in railways, became engineer-in-chief for those lines. Mr. Deane died suddenly on March 12 at his residence in Malvern, Victoria.

Born at Clapham on March 26, 1847, Henry Deane entered Queen's College, Galway, at the age of 15, finally graduating in Arts with Honours, after which he attended King's College, London, for the study of engineering subjects. His pupilage was served under Sir (then Mr.) John Fowler. During this period he was engaged on portions of the Metropolitan Railway. In 1869 he went abroad in connection with the construction of the East Hungarian Railway Company's system, later becoming connected with the Danube Steam Navigation Company at Buda-Pesth. At the age of 28 he was back in England and working under Sir (then Mr.) Benjamin Baker, for whom, in 1877, he went to Manilla, in connection with the erection of sugar plant. On the completion of this, and having returned to England he proceeded to Australia, where he obtained an appointment as surveyor on the New South Wales railways and was engaged on the section of the Great Northern line extending from Mullet Creek to Ourimbah. In 1881 he was made district engineer and subsequently was in charge of the construction of the lines from Gunnodah to Narrabri and from Homebush to Hawkesbury. The year 1884 saw him transferred to Sydney, where in 1889 he followed Mr. John Whitton as engineer-in-chief for the railways.

In this capacity he paid visits to America and Europe in 1894 and 1904 in connection with light railway and tramway matters. He retired from the State Service in 1906 to take up consulting work, but in 1911 was appointed consulting engineer to the Commonwealth Government for the survey of the Transcontinental Railway between Port Augusta and Kalgoorlie. In the following year he was appointed engineer-in-chief for the Commonwealth Railways, relinquishing this post in 1914.

Mr. Deane was elected an associate member of the Institution of Civil Engineers in 1874, being transferred to full membership in 1886. On Colonial representatives being appointed to the Council he had the honour of being the first to hold that position for Australia. He was a Fellow of the Royal Meteorological Society, and of the Linnean Society of London, being a keen botanist and especially interested in the timbers of Australia. For two years he was President of the Linnean Society of New South Wales, being also twice elected President of the Royal Society of New South Wales, as well as one of the early Presidents of the New South Wales Institution of Surveyors.

THE STATE OF THE ELECTRICAL INDUSTRY.

IN his address to the British Electrical and Allied Manufacturers' Association at their annual luncheon in the Connaught Rooms on March 20, Mr. B. Longbottom stated he saw evidence of a return to greater activity in the growing restlessness of labour. Already two strikes of national importance had been negotiated, without risking any of the first movements towards trade recovery. The threat of a greater national danger than any through which we have passed, the coal wages dispute, might induce a spirit of pessimism, but the interests of Labour and Capital were now so closely interlocked that labour itself had ceased to be revolutionary and was alive to the value of conciliation. There was no doubt, however, that industry was improving. This opinion had been cautiously advanced by the chairmen of five great banks, in their annual speeches to the shareholders, and the main symptom on which their diagnosis was based, the increase in advances made by the banks for trade purposes, had, if the returns for January and February were considered, shown a marked tendency to become more powerful still.

The electrical industry had been more continuously employed then, perhaps, any other industry since the conclusion of the war. The re-organisation of the generation and distribution of power laid down in the Electricity Act of 1919 had steadily progressed. The virtual conclusion of the legal dispute regarding the London and Home Counties Electricity District added a third district to the two already determined, the South East Lancashire and South West Midlands Districts, and it was probable that this year would see the completion of investigation into the West of Scotland and the West Riding (Aire and Calder) Districts. Those five schemes covered the most important industrial regions in Britain. The importance of research had long been recognised in the United States, France and Germany, and we were behind those countries in provision for such work.

In January, 1924, only 5·9 per cent. of the insured workers in electrical engineering were unemployed, compared with 19·1 per cent. in general engineering and 11·8 per cent. in all industries. It is certainly true that this activity in the electrical industry had only been achieved by considerable sacrifice, as it has been the consistent endeavour of employers to secure contracts, often at most unremunerative prices. By this means they had been enabled to keep their workpeople together, the importance of which, irrespective of the humane point of view, could not be over-estimated.

Electrical manufacture had returned definitely to the level fixed by the relation between productive costs and selling prices which existed before the war, and as a result of immensely increased taxation, this level meant a considerable reduction in profits. The analysis made by the *Economist* from the reports of 1,351 companies in all industries showed that the percentage of net profits earned to the ordinary capital invested was 9·3 per cent. in 1923, compared with 10·2 per cent. in 1913. A similar analysis made for the electrical industry alone showed a ratio not exceeding 7 per cent. in any year since 1921. The menace of competition from abroad in the home market was a danger which must continually be faced. The British manufacturer was wholly unprotected against competition from countries with depreciated exchanges and a low standard of living. The policy of buying in the cheapest market was dangerous, not only to industrial prosperity but also to social progress. The foreign markets presented many points of interest during 1923 and the position of Britain in electrical exports improved considerably, even if the comparison included the record year, 1921. The initiation of important hydro-electric schemes in the Dominions, the progress of railway electrification in South Africa, Japan, Brazil and India, the opening up of new markets in the Baltic States and the continued activity of the Australian market had combined to make the past year one of the most notable in the post-war period.

PALMER-CAMELLAIRD-FULLAGAR OIL ENGINE.

SINCE the publication in ENGINEERING of August 31, 1923, of a description of the Palmer oil engine built under the Camellaird-Fullagar patents, a series of test-bed trials have been conducted by Engineer-Commander Hawkes, Professor of Engineering at Armstrong College, Newcastle-on-Tyne. Through the courtesy of the constructors we are enabled to present the results, as was promised at the conclusion of the descriptive article. The object of the trials was principally to determine the fuel consumption per brake horse-power hour at various powers. Tests of two or three hours were run during each of which the power and revolutions were arranged to follow the requirements of the propeller law as closely as possible. The power was absorbed by a Heenan and Froude dynamometer. At the commencement of each test fuel was drawn from one tank and at the end of 15 minutes this tank was shut off and the second connected to the suction pipe and an accurate record of the consumption every 15 minutes was thus ensured. All the instruments were carefully calibrated before the tests. Persian fuel oil was used and samples were taken during each trial and analysed and the calorific value determined.

Averages of Trial Results.

Load.	Quarter.	Half.	Three-quarters.	Full.
Duration of test, hours	2	3	3	3
Revs. per minute	57·7	70·0	76·9	85·4
B.H.P.	815	1,484	2,115	2,765
Fuel per lbs. per b.h.p. hour ..	0·463	0·422	0·404	0·405

The main engine drives the circulating pump for jackets and piston cooling, the forced lubrication pump and the scavenging pump which absorb in all about 150 b.h.p. The results must be viewed in the light that no allowance was made in them for this, and that the oil used was not of the highest calorific value obtainable.

The brake thermal efficiency of the engine, taking the lower calorific valve of the fuel as 17,730 B.Th.U. per pound, was found to be 35 per cent. for the mean results of the full power trial. The exhaust was quite colourless during all but the quarter load test, when a slight haze was produced. The engine was under close observation during the whole period of the trials, and Engineer-Commander Hawkes' report shows that it ran smoothly and well without a stoppage of any kind. Further tests are, we understand, to be undertaken by the Marine Oil Engine Trials Committee of Institution of Mechanical Engineers.

PORTABLE LOGGING SAW AND PETROL ENGINE.

CONSTRUCTED BY MESSRS. DRUMMOND BROTHERS, LIMITED, ENGINEERS, GUILDFORD.

Fig. 1.

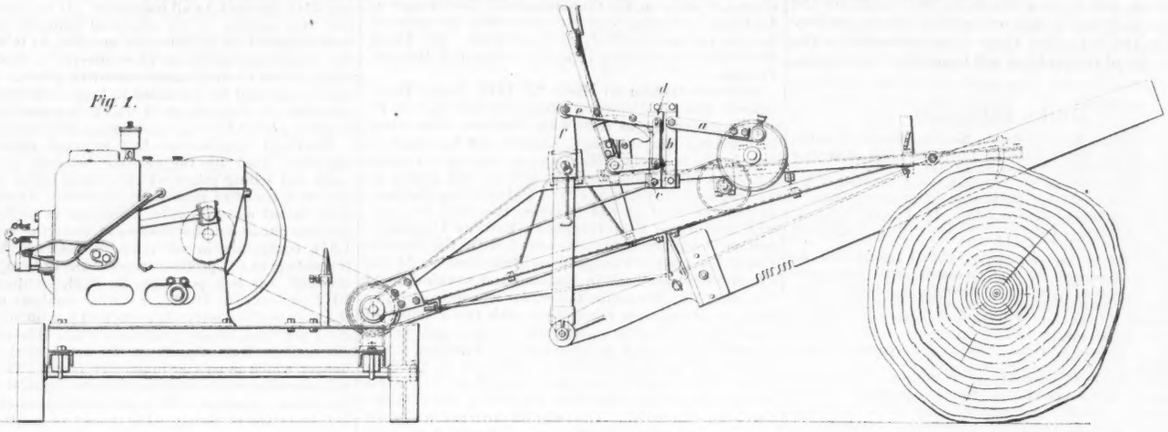
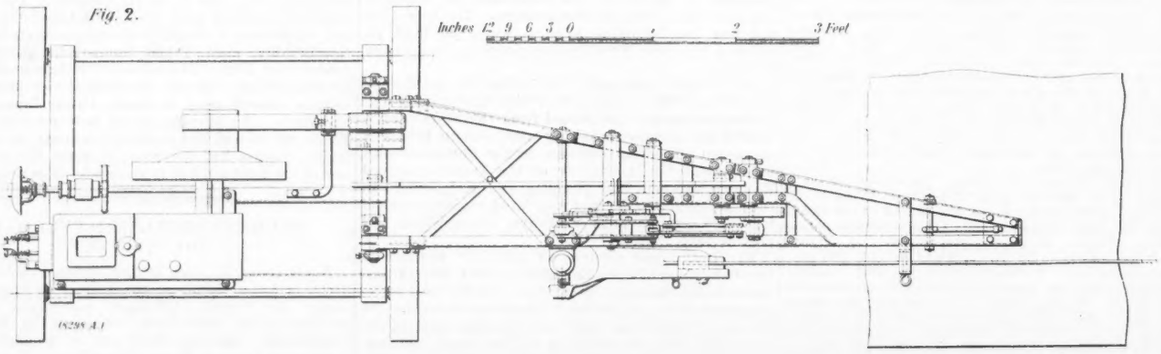


Fig. 2.



THE development of the small petrol or paraffin engine in a portable form has led to its application to many of the duties about a farm or estate which were formerly performed in an expensive and laborious way by manual labour. Some years ago Messrs. Drummond Brothers, Limited, of Guildford, Surrey, put upon the market a well constructed and inexpensive engine, specially designed for the conditions under which agricultural engines have to work, the intention of the makers being to provide a really serviceable power unit to compete with the cheap and often rubbishy imported engines. The Drummond engine, sold under the name of the 'Willing Worker," proved very successful, and the firm proceeded to develop various appliances and machines to be used in connection with it. We illustrated and described the engine very fully in our issue of December 8, 1922, and have made several subsequent references to its applications. Its latest field of usefulness is in connection with the driving of logging saws, Messrs. Drummond Brothers having recently designed the portable unit, consisting of engine and logging saw, which is illustrated in Figs. 1 to 3 on this page.

The arrangement is interesting in many ways, the mechanism for operating and controlling the saw being of a much more satisfactory kind than is usually employed on apparatus of this nature. The engine is carried on a truck built up of channel steel, the wheels of the truck being parallel to the log being cut, so that the whole machine can be easily pushed into position for a fresh cut. The engine develops 3 b.h.p. at 600 r.p.m., using either petrol or paraffin for fuel. It drives a countershaft on the truck by means of a belt, and from this countershaft a chain and sprocket drive is taken to a second shaft situated at about the centre of the saw-frame. The chain drive gives a speed reduction of 30 to 20, and a spur reduction gear on the second shaft, with a ratio of 5 to 1, brings down the speed of the crank which operates the saw to 80 r.p.m. The whole saw-frame is pivoted about the countershaft on the truck so that it can be raised or lowered without affecting the drive to the crankshaft.

Reference to the illustrations will make it clear how the saw is driven and controlled. The crankshaft to which we have already referred is in continuous rotation, and by means of the connecting rod *a* (Fig. 1) keeps the link *b* oscillating about the centre *c*. The hinder bar of the link acts as a slide for the gunmetal block *d*, which can be raised or lowered along the link by the manipulation of the hand-lever shown. The block *d* is also attached by links *e* to a lever *f*, the oscillation of which causes the strokes of the saw. It is clear that if the hand lever is in the backward position shown in Fig. 1, the block is at the uppermost part of its link opposite the end of the connecting rod and therefore gets the full motion due to the crank. This is the working condition under which the saw makes its full stroke. If the hand-lever is set forward in the quadrant provided for the purpose, the block *d* is held nearer the centre about which the link oscillates and, consequently a shorter motion is imparted to the saw. At starting, the operator places the hand-lever in its foremost or non-operative position, and then starts the crank motion. The saw is then placed ready for the cut, and the hand-lever brought back to the first notch in the quadrant. A short stroke is thus given to the blade, which, consequently, starts very steadily into the wood. As soon as the cut has properly commenced the hand-lever may be brought right back, so that the saw works with its maximum stroke. Just before the log is severed the hand lever is again brought forward and the stroke

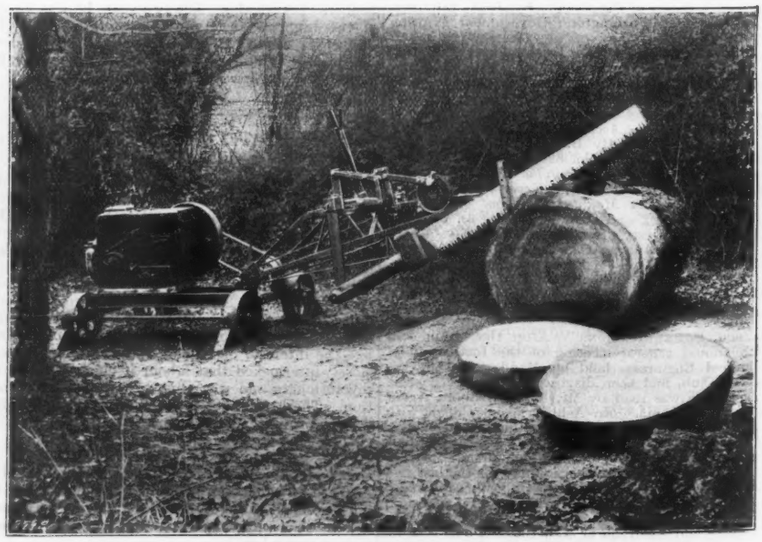


FIG. 3. LOGGING SAW AT WORK.

shortened, as the cut is completed the lever is put into its foremost position, so that the motion of the blade is stopped and it does not slash into the ground.

It will be seen that starting is a simple and safe operation, and an unskilled operator can use the saw with perfect ease. At the beginning of the stroke the saw blade is guided by two blocks of wood, which are held in a clip and bear lightly against the sides of the blade until it has fairly entered the wood. The further guidance of the blade is effected by the cut itself, but the rigid manner in which the saw is held also eliminates the tendency to wander, so that the machine makes the straight, true cut which is so desirable, especially where valuable timbers are concerned. The saw frame is a stiffly designed, though light structure, and the spread of its base, where it is hinged to the truck, ensures lateral rigidity. It becomes narrower towards the log, to which it is attached by a single spike at the apex. This appears a decided improvement upon the method adopted in some machines of having the broad part of the frame carrying the saw resting on the log. In the Drummond arrangement only the apex of the saw frame rests on the log, with the result that, no matter how uneven the shape of the log, a good attachment can always be obtained without the use of packing and furthermore, the cut can be made in a position quite close to the end of the log. Thus, not only can the last short section of timber be cut up, but the log can be cut off close alongside the roots or other projections.

When shifting from cut to cut the blade can be held up out of the way in the guide clips shown in Fig. 1. For transportation from one place to another, the blade can be removed and the saw frame swung backwards, so that the machine will pass through any place wide enough to clear the wheels of the truck. A further feature which promotes portability is that all connections are made with bolts, instead of rivets, thus enabling the whole machine to be reduced to its component parts for transport through forests or over mountains, where no road or trail exists. The ordinary saw blade supplied with the machine is 6 ft. long, such a blade being shown in use in the photograph reproduced in Fig. 3. A blade of this length will cut logs up to 3 ft. diameter, but blades of 7 ft., 8 ft., and 10 ft. length are supplied for larger work. Messrs. Drummond Brothers recommend their "Willing Worker" engine, arranged for petrol as fuel, as the most suitable power unit for the combination; they point out that, of course, other engines can be used if desired, the change usually involving nothing more than a re-arrangement of the bearers on the truck.

THE OXYTOME METAL-CUTTING MACHINE.

THE advantages of the oxy-acetylene flame for cutting metal have been recognised for many years, but the process is associated in the minds of many engineers only with the cutting up of metal for scrap purposes, or similar rough classes of work. The development of the method, however, has resulted in the production of machines for the accurate manipulation of the cutting flame, and consequently a variety of work can now be done by the oxy-acetylene process which will compare in finish with the work of ordinary slotting, sawing, shaping and milling machines, with the advantage of much greater rapidity. Moreover, for certain jobs, such as the cutting out of complicated shapes from metal plates, the oxy-acetylene method is quite unrivalled, as no ordinary cutting machine, with the possible exception of a band-saw, could perform the work at all, and even a band-saw could not do it nearly so well.

It is a tribute to the precision with which the oxy-acetylene flame can be made to cut that Messrs. Alfred Herbert, Limited, of Coventry, should have developed a machine for ordinary workshop purposes by the use of which iron and steel plates can be cut to any regular or irregular form of profile. This machine, which is illustrated in Figs. 1 to 3 on page 402, is known as the "Oxytome," and will cut any required shape out of plates up to 12 in. thick. Its general construction will be understood from Fig. 1. At the back of the machine are two standards, connected together by cast-iron girders, which form slides carrying movable arms projecting towards the front of the machine. These arms are independent of each other except for the connecting mechanism shown in Fig. 2. The work lies on the supporting steel joists, which are themselves adjustable for height by means of the crank-handles seen in Fig. 1.

The blow-pipe is supported by a saddle which can be moved along the arm projecting from the lower of the two cross-girders. The cutting flame can therefore be traversed in any direction whatever, following either a straight or a curved path along the work, the two components of its motion being provided by the respective movements of the saddle and of the arm. As the moving parts are fitted with rollers which run on ball bearings, the frictional resistance is negligible, and the saddle will respond to the touch of a finger in any direction if the mechanical traversing gear is disconnected. For profile work such as the manufacture of links for Stephenson link-motion or of other shapes, a former is mounted on arms extending from the top of the machine. The arms, with the former attached, can be swung up out of the way so as to enable work to be placed in position by a crane.

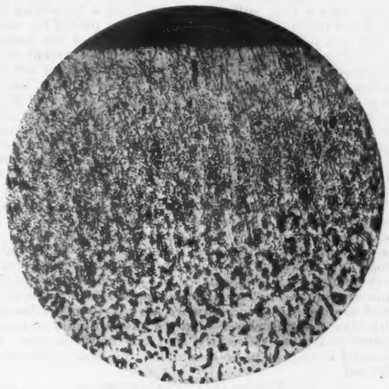


FIG. 4. SMOOTH CUT THROUGH MILD STEEL ½ IN. THICK.

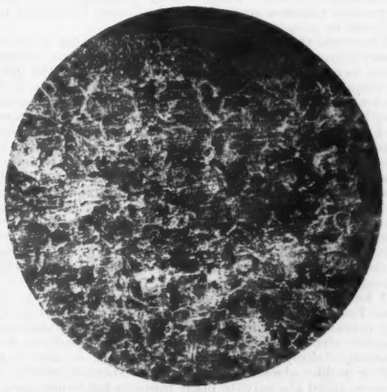


FIG. 5. SMOOTH CUT THROUGH 0·5 CARBON STEEL 3 IN. THICK.

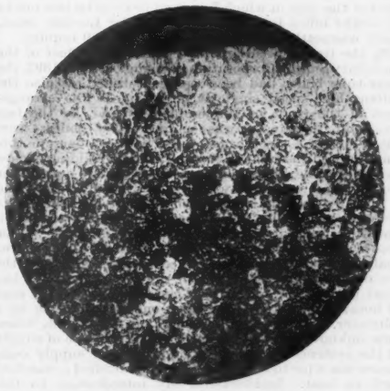


FIG. 6. ROUGH CUT THROUGH 1·0 CARBON STEEL 1 IN. THICK.

The guiding and feeding mechanism for the blowpipe is carried by the arm projecting from the upper girder. This arm is provided with automatic variable feeds, power being furnished by a ¼ h.p. electric motor. The function of this upper arm is to guide the blowpipe in straight lines, which may be either longitudinal or transverse or at any intermediate angle desired. When a circular hole has to be cut, the arrangement is as shown in Fig. 2. A pin in the top of the cutter saddle is inserted into a hole in the underside of the cross-head depending from the saddle on the upper arm, and the pin-hole is adjusted to the desired radius from the centre of rotation of the crosshead. When the crosshead is caused to rotate, the saddle with its cutting flame has to follow a circular path about the same centre, this being permitted by the combined motions of the cutting saddle along the lower arm, and the lower arm along its supporting girder.

For curves other than truly circular ones, the former is employed. The cutting saddle is then not directly connected to the crosshead, but is attached to it by a rod, by means of which it is towed along as the upper arm is traversed along its girder. The towing rod allows the saddle to follow the contour of the former, against which its guiding pin is held by the action of a weight and cord. The machine, doing contour work, is shown in Fig. 1. All feed motions are reversible, and adjustable automatic stops are provided. The feed mechanism and the control of the longitudinal traverse, and circular motions are operated from one position at the end of the upper arm.

The cutting blowpipe has three flexible gas supply pipes, one for acetylene, or coal gas if acetylene is not available, and two for oxygen. One of the latter supplies oxygen for the combustion of the acetylene, and the other furnishes the oxygen which cuts, or rather oxidises away the metal which has been heated by the other part of the flame. The gases are turned on in their proper order and also ignited by the single movement of a lever. The arrangement can be seen in Fig. 3, the handle of the lever being shown just under the tape binding the flexible pipes together. Movement of this lever to the left causes the slotted cam-plate also to move to the left and at the same time operates an igniter of the cerium, or so-called "flint and steel" type, close to the end of the blowpipe. It will be seen that the position of the two gas taps is determined by the position of the slotted plate. As the plate is moved to the left the acetylene tap, connected to a pin in the farther slot, is opened by the zig-zag in the slot, the oxygen cock remaining closed. The latter cock is not opened until the plate reaches the end of its travel and after the acetylene has been ignited by the spark. When it is required to shut off the flame the handle is moved in the reverse direction. The pin controlling the oxygen tap does not return by the same slot as it traversed before, but makes a circuit, so that the oxygen is not shut off until after the acetylene tap has been closed by the zig-zag in the slot for the acetylene control. Hence there can be no possible mistake in the order in which the cocks are opened and closed, and the automatic ignition of the jet is also, of course, a great convenience. The cutting jet is controlled by a valve on the blowpipe.

The machine illustrated will deal with work up to 3 ft. 9 in. wide by 7 ft. 6 in. long. It is, however, so designed that additional standards can be erected and the girders extended, giving an additional working length of 10 ft. with every extension unit added. It can thus be used for long work such as the cutting out of locomotive side frames, the arrangement for swinging the former plate carrier out of the way of an overhead crane making it particularly handy for such work. The machine will deal with iron and steel plates from ¼ in. to 12 in. thick, and is universal in its movements. It will cut any shape whatever, whether bounded by straight or curved lines and with sharp or rounded corners. Bevelled work can also be done if desired. The finish of the work cut by the flame is extraordinarily good, the edges are left perfectly sharp, and the cut surface is very much smoother than much of the work which is ordinarily produced by a slotting machine or saw. The machine can be controlled by a single operator, and the whole of any cutting operation can be performed without any resetting of the work. As regards the speed of cutting, we understand that, when working on ¼ in. plate, cutting is done at the rate of 65 ft. run per hour, with an oxygen consumption of 0·75 cub. ft. per ft. run of cut. Plates 1 in. thick are cut at 40 ft. run per hour, with an oxygen consumption of 2·2 cub. ft. per ft. run. Plates 2 in., 4 in., 6 in. and 12 in. thick, are cut at speeds of 25 ft., 20 ft., 18 ft. and 13 ft. per hour, respectively, with oxygen consumptions of 5 cub. ft., 15 cub. ft., 24 cub. ft. and 50 cub. ft. per ft. run of cut. The consumption of acetylene is so small that the cost is relatively insignificant.

The question of the action of the oxy-acetylene flame upon the steel in the neighbourhood of the cut has sometimes been raised, because if any injury to the nature of the metal were caused, the process might be inadvisable for work subject to stress in use. Messrs. Alfred Herbert, Limited, have therefore carried out a large number of experiments upon this point, the result of which is to show that in the case of ordinary mild steel such as is used for boilers, bridges, &c., no effect of any kind can be detected. Tests were then made upon a piece of steel of the kind often used for lathe spindles, this material having a carbon content of 0·52 per cent., with manganese to the extent of 0·82 per cent. The effect of the cutting was that the cut surface was decarbonised by the flame to the depth of 0·007 in. A skin, 0·010 in. thick, was then removed from the surface, and the metal beneath was tested for hardness. On the small Brinell machine the hardness number was 418, indicating that the steel was hardened to some extent. After removing a thickness of 0·02 in. from the original surface, the hardness number was

364. When one-sixteenth of an inch was removed, the hardness was 269, and the removal of three more sixteenths successively, gave respectively 207, 187 and 170 as the hardness numbers. The natural hardness in the centre of the sample was 170, so that it will be seen that the whole of the extra hardness due to the cutting was removed by machining off a quarter of an inch from the original surface.

The sub-surface hardness is, of course, due to the chilling of the metal by rapid cooling after the heat of the flame. The figures quoted above indicate that on high carbon steel, machining would be difficult unless about 0·05 in. were removed from the surface, so as to reduce the hardness to about 285. With a heavy cut, the surface hardness would give no trouble, as the tool would easily get under the hardened portion. With steel having a higher carbon content than the sample referred to, the effect of rapid cooling after cutting would be to increase both the hardness and the "depth of chill." On the other hand, with carbon below 0·30 per cent., the hardening would be negligible. The nature of the steel in the neighbourhood of the cut has also been studied in Messrs. Alfred Herbert's laboratory by means of microphotographs and chemical analysis, and the results generally confirm the conclusions we have stated.

In view of the importance of the question we will summarise the findings of the laboratory in respect of three classes of steel, namely mild steel containing up to 0·35 per cent. carbon. Medium steel with about 0·5 per cent. carbon, and steel with 1 per cent. carbon. The effect of the oxyacetylene flame depended considerably upon whether a smooth or rough surface was left on the cut metal. With a smooth cut through mild steel plates from 0·5 in. to at least 2·5 in. thick, the metal was only decarbonised to a depth of from 0·003 in. to 0·006 in. from the surfaces of the cut. It was not burnt, and overheating was neglible, so that no weakening effect would be caused by the cut. When a rough jagged edged cut was made, the steel was decarbonised to a depth of $\frac{1}{32}$-in. The extent of decarbonisation depended largely upon the conditions and particularly upon the speed of working, and with very poor hand-cutting the effect would be noticeable to a depth of about $\frac{1}{8}$ in. The microphotograph, Fig. 4, shows a sample of $\frac{1}{2}$ in. mild steel plate, having 0·19 per cent. of carbon, after having been severed by a smooth cut, the magnification being 60 diameters.

Fig. 5 shows a similar microphotograph taken from the sides of a smooth cut through medium (0·5) carbon steel, 3 in. thick, the magnification being again 60 diameters. With fairly good cutting the decarbonised layer was about 0·005 in. thick. The effect of overheating was more noticeable than in the previous sample, but was not serious. For a depth of about $\frac{1}{32}$-in. the strength and ductility of the material were reduced by about 25 per cent., but it would be quite unnecessary to remove this metal by machinery. Under the decarbonised skin, a distinct hardening was observable, the Brinell number, when the 1 mm. ball was used, being 330. A sample of similar steel, badly cut with the flame, was decarbonised to a depth of about 0·05 in. and showed signs of overheating to a depth of $\frac{1}{8}$ in. below the jagged surface.

The third microphotograph, Fig. 6, shows the effect of the oxyacetylene flame on a steel containing 1 per cent. of carbon. The specimen was badly cut so that any injury to the metal would be emphasised. It was decarbonised to a depth of about 0·05 in., and was appreciably hardened to a depth of 0·125 in., the greatest hardness, just under the decarbonised skin being 444 Brinell. After $\frac{1}{16}$ in. had been removed from the cut surface, the remainder of the metal would be easily machinable. With good cutting, it seems quite safe to say that, the effect of the cut on the strength of ordinary mild steel is quite neglible and cracks are not likely to start from the cut surface than from the surface of an ordinary sheared cut.

THE INSTITUTION OF MECHANICAL ENGINEERS.

Address by the President, MR. WILLIAM H. PATCHELL.*

My distinguished predecessor has left on record that he had a business of his own in 1861. I came on the scene a year after that, and nearly sixteen years later my father sent me to the firm of Robey and Co., Lincoln, where I served a full five years' apprenticeship in the shops, while book-work and drawing had to be done in the evenings, followed by three years on outside work. The time spent in the shops by day and extra hours at night in the testing sheds I never regret. It was hard work admittedly, a fifty-four hours good slogging week, not counting the extra hours when I was only there by the kind indulgence of foremen who have long gone to their well-earned rest. To those extra hours I owe the preparation to attend exhibitions, and take charge of the engines the firm lent for driving various classes of machines. In that way I saw the introduction of roller flour mills into this country, and the application of the compound system to steam engines used for agricultural purposes. A red-letter day brought instructions to go to Paris and relieve a homesick man engaged on running the engines for driving the arc light machines on the Anglo-American Brush Company's stand at the first Electrical Exhibition in 1881. Three months there helped one to feel one's feet, so that later on six months alone in Spain helping to introduce the arc light in four of the principal cities, came naturally and went quickly. It has been a long stiff climb from such a beginning to the proud position in which you have now placed me, and I only put it on record to encourage some of the young men who may need a word of cheer. The present day advantages and advances in technical education are of tremendous assistance, and a huge saving of time, but I am not going to say that students will remember all they are supposed to learn as well as if they had to dig it out for themselves. The point that appeals to me so very strongly is that they now have opportunities to learn how to learn, and so should later on cover much more ground with enormously decreased effort; nevertheless, that effort must never slacken off.

I have chiefly dwelt on the practical side of training, but both in that and in the theoretical side the newer methods evolved allow us to save much time, and it is the time saved that must be turned to beneficial use and progress. Old methods, good and effective as they may have been, are no longer possible. We cannot afford the time so spent. The fundamentals upon which we have to build are the same—perhaps we are apt to take liberties with their bearing power—but we have to build so much higher and more efficiently that our methods must be changed to permit us to accomplish our task in the time allotted.

PERSONAL EXPERIENCES.

Some of my predecessors in the chair have left on record a note of some of the blazes they have made or followed which inspire others. I hope I may be equally fortunate in putting together some notes which may be helpful as a record of progress in prime movers.

The work that we apprentices were sent out to with steam-engines generally influenced our future career. Some went to sugar or tea plantations, some to the gold or diamond fields. My turn came in connection with electrical work. Let me recount some of the progress that I have seen in prime movers for electrical generators. As I stated, while still an apprentice I was sent to the first International Electrical Exhibition in Paris, 1881, to take charge of steam-engines driving Brush arc dynamos. The steam-engines were of the Robey semi-fixed type, that is, a horizontal engine under a locomotive type boiler, 80 lb. per square inch working pressure. The engine running at 110 r.p.m. had ordinary slide-valves and wire-drawing governors, which for steady load conditions served the purpose. The size of the dynamos employed varied from 12 kw. to 40 kw., and were all belt-driven off a long countershaft.

I had eight years in a manufacturing business in the East End of London making storage batteries and supplying private electric light plants chiefly run by town-gas engines, although we also used the earliest Priestman and Hornsby-Ackroyd oil engines. This was in the days before public electricity supply was started, which, of course, killed the private plant business for banks, insurance companies, &c. We tried to get into the public supply business to sell batteries, and there must have been some prophetic influence at work which caused the plans of the area in which I worked later to be laid out in my works office for use in the fight for London areas, which was settled by Major Marindin's 1889 inquiry.

By the time I was appointed Engineer-in-Chief of the Electricity Supply Corporation, Charing Cross, in 1893, the water-tube boiler had been well established, as also the Willans high-speed single-acting engine. The arrangement of the plant in Maiden-lane, Strand, by the late Dr. John Hopkinson was unique. The boilers were placed under a steel-legged table with a concrete top, which carried the steam dynamos and the building enclosing them. The exhaust steam was carried up outside the chimney in a steel pipe which caused condensation, and so liberally besprinkled the neighbourhood. The steam pressure was 150 lb., the valves of the then well-known central piston type, and the governors—hopeless! The sizes of the dynamos were 50 kw., 80 kw., and 100 kw. Realising that, in the face of keen competition from the two other supply companies in the area, a steady electrical pressure of supply was essential, we kept a man all hours at the stop-valve of an engine regulating by a voltmeter. This worked so well that an exhibit, taken quite unknown to me, of records of the pressure of supply on the systems of various London electric supply companies was a jar to our friends, and established a standard hard to beat. Incidentally, my introduction to this Institution was through our esteemed Past-President, Sir Alexander B. W. Kennedy, F.R.S., in connection with the addition of steam superheaters and induced draught fans which I introduced at Maiden Lane. (Proc. I.Mech.E. 1896.)

The first power station—we called them electric light stations in those days—that I was responsible for designing was started in 1896 in Lambeth. Here marine type boilers were first employed, but later Hornsby water-tube boilers, 160 lb. pressure, all provided with superheaters bringing the steam temperature up to 500 deg. F., and a separate economiser in the top of each boiler making self-contained units.

Belliss and Morcom double-acting engines with forced lubrication were used. The first sets were 250 kw., three-crank, six-cylinder compound, the last 750 kw., three-crank triple expansion, the orders in each case being for the first of the respective patterns. This station was for, so to speak, bulk supply, as the whole of the current at 1,100 volts direct current was sent to sub-stations in the Strand district, where it was transformed to 100 volts or 200 volts by variable-ratio rotary transformers working in parallel with the old machines in the station in Maiden Lane. The engines were run on their governors and the electrical pressure hand-controlled by rheostats in the fields of the generators.

The increase of the area of supply by the addition of the City of London and the demands in the Strand district called for a larger station. A site at Bow, E., outside the L.C.C. area was chosen in 1899 as giving facilities for steel chimneys and other economies which were prohibited under the L.C.C. Regulations.* Larger boilers were adopted as more suitable for the larger generating units. The station was started in 1902.

At first horizontal water-tube boilers by Hornsby were adopted with heating surfaces of 4,590 sq. ft. and 8,100 sq. ft., respectively; again, all were fitted with McPhail steam superheaters. The steam pressure was 160 lb., temperature 500 deg. F.

The following year vertical tube boilers were added, which I erected in pairs, but by leaving out the middle wall they were operated as single boilers of 21,700 sq. ft. heating surface, instead of separately as originally intended.

The convenience and freedom from smoke due to the large combustion chambers was very marked. They were the first big boilers. I introduced them to Mr. Alex Dow, President of the Detroit Edison Company, in 1905; he saw the possibilities, seized the idea and has ever since consistently adopted and developed it with very marked success.

At that time, twenty-five years ago, the turbine had not settled down as a prime mover which could be sufficiently relied on, so 800 kw. Belliss and Morcom triple-expansion high-speed engines were used for the small units, and Sulzer Bros. 1,800 kw. horizontal cross-compound engines, running 84 r.p.m. for the large ones, these being supplemented a little later by two 4,000 kw. Sulzer three-cylinder compound vertical engines. The expected load factor and the price of coal were such as did not justify an investment in four-cylinder horizontal triple-expansion engines with their higher steam economy.

When I was in America in 1905 I saw the "Manhattan" type, 7,500 i.h.p. (5,000 kw.) Allis-Chalmers combined double horizontal and vertical steam engines working in the Interborough Rapid Transit Company's 59th-street station, New York. These were probably the largest reciprocating engines ever used for the purpose. Subsequently, in 1909, their barometric condensers were removed, and exhaust steam turbines with surface condensers put in their place. This increased their output from 6,000 kw. at 17·7 lb. of steam per kilowatt-hour to 15,000 kw. at 13·7 lb. These fine sets have succumbed to the exigencies of economy, both of fuel and space, and have been removed after being cut up with a blowpipe. *Sic transit gloria mundi.*

During the latter part of these years Sir Charles Parsons' epoch-making invention was advancing rapidly. The resultant economies due to the better utilisation of the materials of construction and of the heat supplied have compelled the adoption of the steam-turbine in every field. The geared turbine has given great satisfaction for house-service machines, and while the attempts to marry the slow-speed ship's propeller to the high-speed turbine have not been uniformly happy, the give and take which promotes happiness elsewhere, has now been appreciated as necessary, and provided as the only alternative to the absolutely perfect workmanship and material which no engineer, not even the British, can guarantee every time.

Without the turbine, steam power development could never have progressed as it has. I have shown that 5,000 kw. to 7,000 kw. was about the limit so long as we depended on the reciprocating engine as the prime mover. By the aid of the steam-turbine 50,000 kw. generating sets are equally practicable, and units of a size which formerly were main generating units are now needed for the house supply in main power stations. We welcome the turbine, too, as giving us pure condensate which can be re-used in the boilers without anxiety; a most important matter, so that its advent is as great a blessing in the boiler-room as it is in the engine-room.

Thermal Valuation of Power Stations.—So far as I have ever heard, the first figures published showing the thermal efficiency of electric power stations on units delivered were those in the I.E.E. Journal, 1906, vol. xxxvi, pages 154–7. The best then were :—

	B.Th.U. per Kw.-hr.	Efficiency. Per Cent.
Berlin	29,440	11·58
Carville (6 months)	39,130	8·72
Boston, Mass.	45,450	7·51
Glasgow	47,250	7·22
Manchester	48,200	7·08
Charing Cross (Bow)	50,960	6·70

The thermal basis of comparison was used again in 1918 by Mr. David Wilson for the Coal Conservation Committee, and has since been adopted by the Electricity Commissioners in their annual report. It still seems to be the exception rather than the rule to record the particulars necessary for obtaining the figures correctly, but the real advantage of so doing is gradually becoming appreciated.

Mr. Wilson's records were of groups, not of individual stations, as various managements prohibited the publication of individual operations. He records forty stations, which generated practically half of the total amount of electricity used in this country, as working at 11·5 per cent. efficiency, the other 381 were only working at 6·8 per cent. efficiency. In the group of the best 40 were 7 stations generating between them 1,299,000,000 units, showing an average thermal efficiency of 12·12 per cent., the best record being 12·35 per cent. for an output of 46,000,000 units.

The Electricity Commissioners' 1923 Report, taken on units generated, shows a considerable improvement on these figures. Five steam stations there quoted are

* Abstract. Delivered on Friday, March 21, 1924.

* The work was described in the I.E.E. Journal, 1906.

much better than the best recorded five years previously :—

Newcastle Co., Carville B ..	17·80	thermal efficiency	per cent.
,, ,, North Tees	17·15	,,	,,
Rotherham	16·70	,,	,,
Newcastle Co., Dunston ..	16·50	,,	,,
Hackney, London, E ..	15·40	,,	,,

The highest thermal efficiency, however, may not always mean the lowest fuel consumption, although it generally does so. It is a matter of commercial as well as thermal economy. It sometimes pays to burn a larger quantity of low-grade fuel than a lesser quantity of high-grade fuel, and sometimes this position is reversed, as we cannot get any thermal units out of freight or costs of handling. This, however, does not upset the truth of the general proposition, that the best method of stating steam power station economy is to give the B.Th.U. in coal per kilowatt-hour sent out of the power station, as it is a very good criterion of both the design and the operation of the station.

TABLE 3A (PART).

—	Millions of Units d/d to Mains.	Load Factor (on 30-minute Max. Load).	B.Th.U. per Kw.-hr. d/d.	Thermal Efficiency per cent. (on Units d/d).	Units Sold. Total in Millions.	Units Sold. Per Head of Population.
Glasgow Corporation	—	—	—	—	200·00*	193*
Dalmarnock	183·20	27·6	20,150	16·94	—	—
Newcastle E.S. Company	—	—	—	—	—	—
Carville B.	234·27	48·5	20,720	16·47	—	—
Newcastle E.S. Company	—	—	—	—	—	—
North Tees	97·95	34·4	21,130	16·15	—	—
Clyde Valley E.P. Company	—	—	—	—	—	—
Clyde's Mill	69·36	44·0†	21,810	15·65	—	—
Lancs. E.P. Company	—	—	—	—	—	—
Radcliffe	101·20	31·0	21,950	15·54	—	—
Stepney Boro., London	—	—	—	—	29·95	120
Narrow Street	44·33	27·3	22,350	15·27	—	—
Newcastle E.S. Company	—	—	—	—	—	—
Dunston	128·90	24·9	22,850	14·94	—	—
Hackney Boro., London (M.)	—	—	—	—	18·58	84
Mare Street	20·38	20·6	23,100	14·78	—	—
Central E.S. Company, London	—	—	—	—	—	—
Grove Road	55·69	21·7	23,400	14·58	—	—
L.M. and S. Railway Company	—	—	—	—	—	—
Stonebridge Park, London	53·48	66·3	23,640*	14·44*	—	—
Clyde Valley E.P. Company	—	—	—	—	—	—
Yoker	49·53	22·6	24,050	14·19	—	—
Southern Railway Company	—	—	—	—	—	—
Durnsford Road, London	49·17	43·5	24,400	13·99	—	—
Bolton Corporation	—	—	—	—	40·92	229
Back o' th' Bank	46·76	27·6	24,870	13·72	—	—
Bradford Corporation	—	—	—	—	65·77	226
Valley Road	76·39	27·5	25,010	13·65	—	—
Rotherham Corporation	—	—	—	—	42·98	417
Rawmarsh	55·64	26·5	25,050	13·62	—	—
Manchester Corporation (M.)	—	—	—	—	185·64	218
Stuart Street	200·94	29·9‡	25,140	13·57	—	—
N. Metropolitan E.P.S. Company ..	—	—	—	—	—	—
Brimsdown	31·90	26·0	25,840	13·21	—	—
N. Metropolitan E.P.S. Company ..	—	—	—	—	—	—
Willesden	45·51	29·8	25,980	13·14	—	—

TABLE 3B (PART).

—	Millions of Units d/d to Mains.	Load Factor (on 30-minute Max. Load).	B.Th.U. per Kw.-hr. d/d.	Thermal Efficiency per cent. (on Units d/d).	Units Sold. Total in Millions.	Units Sold. Per Head of Population.
Milwaukee, Wis.	—	—	—	—	—	—
Lakeside	313·84	45·3	18,030	18·93	—	—
Detroit, Mich.	—	—	—	—	1,126·88	715
Marysville	147·95	47·3	18,923	18·03	—	—
Chicago, Ill.	—	—	—	—	2,265·26	785
Calumet	517·71	40·8	19,215	17·76	—	—
Cincinnati, Ohio	—	—	—	—	335·55	447*
West End	410·48	43·8	19,490	17·51	—	—
Philadelphia, Pa.	—	—	—	—	999·65	500*
Delaware	468·35	42·8	19,600	17·41	—	—
Duquesne Light Company, Pa.	—	—	—	—	1,052·93	604*
Colfax	694·08	61·8	19,610	17·40	—	—
Detroit, Mich.	—	—	—	—	—	—
Connors Creek	695·87	49·9	19,666	17·35	—	—
Philadelphia, Pa.	—	—	—	—	—	—
Chester	278·66	52·2	19,930	17·12	—	—
Newark, N.J.	—	—	—	—	876·68	337
Essex	498·73	45·5	20,930	16·30	—	—
Boston, Mass.	—	—	—	—	379·88	301
L Street	482·33	39·0*	21,520	15·86	—	—
Cleveland, Ohio	—	—	—	—	700·71	700*
Lake Shore	778·06	47·7	21,880	15·60	—	—
Chicago, Ill.	—	—	—	—	—	—
North West	813·10	55·5	21,960	15·54	—	—
Baltimore, Md.	—	—	—	—	679·68	850
Westport	390·05	39·7‡	23,450	14·55	—	—
Hartford, Conn.	—	—	—	—	165·95	—
South Meadow	99·44	33·4	23,720*	14·39*	—	—
Chicago, Ill.	—	—	—	—	—	—
Fisk Street	899·34	46·6	24,030	14·20	—	—
Detroit, Mich.	—	—	—	—	—	—
Delray	502·55	53·8	24,464	13·95	—	—
Interborough R.T. Company, New York	—	—	—	—	—	—
74th-street	498·30	40·7	24,750	13·79	—	—
Brooklyn, N.Y.	—	—	—	—	445·00	214
66th-street	215·97	41·1	25,980	13·13	—	—

(M.) Indicates that the figures are for the year ending March 31, 1923 ; the remaining figures are for the year ending December 31, 1923.

* Indicates approximate figures only. † Indicates 15-minute maximum load. ‡ Indicates 60-minute maximum load.

I have lately approached the management of British steam power stations with an output of over 30,000,000 units per annum, and am able by their kindness in nearly all the cases to publish the figures. Some report a transition stage on hand, or do not wish their figures published. Some of my friends in America have kindly supplied their corresponding figures, as has also Colonel Mercier for the Gennevilliers Station, Paris.

I am much indebted and grateful to all these friends for allowing the figures and data given in Tables 3A and 3B (reproduced in part above) and elsewhere in this Address to be published.

The figures are very interesting and instructive, but must not be too closely compared as between stations with different load factors. A plant may be run isolated or as part of a system, and should be run for the best overall efficiency. Take Table 3A. Dalmarnock at the top of it runs alone. The three Newcastle stations are interconnected with each other and with a large number of waste-heat and other stations. Radcliffe is worthy of note, as it shows what can be done with a plant not by any means modern.

The two score years—1881–1923—showed progress in size of units and pressure, but what of the next twenty years ? I have had to consider with my friends in the U.S.A. the arrangement and details of plants incorporating boilers of 30,400 sq. ft. heating surface, 400 lb. working pressure ; turbines of 50,000 kw. capacity, with a single barrel ; also steam-boilers with pressures of 1,200 lb. per square inch with suitable turbines. To give an idea of what these units mean, one of the big boilers such as are now being put down at the Trenton Channel plant of the Detroit Edison Company will generate steam to develop about 25,000 kw. I thought I was doing well twenty years ago in running 4,000 kw. off one boiler. Now such a boiler seems not much more than a kettle !

May we pause a moment to see why such units are not only possible, but practicable, in the U.S.A. ? It is not because American engineering is better, either in design, workmanship, or material than our own ; it is the direct outcome, not of their engineering, but of the skill and zeal of those who handle the sales department of the electricity supply undertakings. No doubt they find customers more ready to listen to their charming but where do we in England hear the voice of such charmers ? Very seldom.

The last column in Tables 3 (A and B) show the kilowatt-hours sold per head of population per annum by several of the British and American undertakings.

The American consumption of electricity per head of population per annum would never have been 500 to 700 kw.-hr. if it had been left to the consumer to go out and buy it. It is because people have, after study, gone out to sell it, and they have sold it. Now the public are not only happy in paying for it, but are eagerly wanting more.

We have a population of some 40 millions and one 30,000 kw. machine. The population of the United States is about 100 millions. I jotted down in an American train last year as many units of 30,000 kw. as I knew were on order, and handed it to a travelling companion to supplement it. We had nothing but our memories to work on, no notes or papers. The list amounted to 915,000 kw. for home supply only. I followed that up by an inquiry to one maker, and heard that they had uncompleted orders for 1,845,000 kw., in units of 20,000 kw. and over, on their books. The figures set one thinking what mechanical engineers might be doing if the electricity supply authorities stimulated a demand.

We heard some time ago that the electrification of our main line railways was being taken in hand, but except for parts which are suburban lines, this appears to be shelved again, in spite of the experience obtained elsewhere. True, the initial capital cost is great, but there always appears to be plenty of money available for those who talk loudly about a case and go in for it. Whether the new types of locomotives and improved design can do more than delay the conversion is a question, but it does seem certain that if one management would only make a start and "go in with both feet," the satisfaction which is being obtained abroad would be reproduced here.

Money spent on engineering equipment in this way would not at any rate be lost, and would have an excellent chance of earning a return at an early date, whereas money spent in maintaining the unemployed workers and their families, who might be engaged on such schemes, is undoubtedly lost. How often, too, do we hear of employers taking on work merely to keep their employees together, without making any allowance in their prices for interest or depreciation charges in respect of plant, the rent, rates and taxes on which have to be paid so long as their shops are in evidence, whether standing idle or not.

Further Developments.—I will now indicate the direction in which progress points at present, and mention some of the limitations.

Since the rapid improvement in the intrinsic efficiency of the steam-turbine began to flag the ability to improve it further by extraneous means has received closer and more attention. The diverse possible means have developed a fascinating field for study. May I try and give some of the high points ? Heat cycles and the tunes that can be played thereon are enchanting.

The generation of steam at the so-called critical temperature, 3,200 deg. F., when its density equals that of water, is, according to notices in the press last year, being tried out on a small scale by the English Electric Company at Rugby. It is highly interesting, but the pressure would appear to militate against its consideration for large power plants in the present state of the art. As this is going to press, I hear the boiler is reported to have been successfully tested at full pressure and 725 deg. F. temperature.

To sum up the matter, with the best of apparatus, design and material now available, we cannot, on paper, see more than one kilowatt-hour produced out of 1 lb. of best Welsh coal. We must, too, always remember that our nearness of approach to this figure depends even more on the load factor and the handling of the plant, particularly in the boiler-room, than it does on the design. The performance of the two or possibly three plants for which 1,200 lb. pressure boilers and turbines are now on order will be watched with much interest. In these cases high-pressure turbine units are being provided which will exhaust at about 300 lb. back pressure, the steam being reheated at the boiler before being turned into the ordinary steam main. An alternative is also proposed of making the high-pressure turbine part of a self-contained two-barrel unit exhausting into its own condenser. Trouble and expense in maintenance will occur in pipes and fittings. In an experimental plant the turbine can be located near the boiler ; in a commercial plant such juxtaposition is not practicable, so unusual expansion strains and differences in lengths have to be provided against. Small leakages occur at normal steam pressures which can be safely allowed to wait till a convenient time without damage to the fittings but at high pressure such details are by no means trifling, and cannot be allowed to wait. They demand instant attention, as the cutting action of the steam will quickly put the fittings beyond repair.

Pipe flanges have been a contributing cause for grey hairs in two of your past Presidents, as in my own case, but so far we have not seriously had to consider welded joints. The tendency is now developing strongly along those lines, and I believe we shall soon find them much more common than they are now. When once pipes are erected and connected up joints are, or ought to be, capable of being forgotten. Why not weld them and put them one stage nearer that goal ? Fittings, I am afraid will, like the poor, be always with us, so perhaps the two classes of joint which would have to be employed are an objection, but I would eliminate all possible sources of trouble or leakage. The ideal metal-to-metal joint has not yet proved satisfactory, except in a "jammed" joint of the Perkins type. Some kind of composition fabric insertion has commonly to be employed. High pressures and temperatures render the use of such insertions undesirable. These structural considerations will I fear, limit the size of high pressure units until more experience has been obtained, and they will no doubt lead to the development of designs of boilers very unlike those now obtaining, while the high steam pressure will tend to decrease the size of the turbine castings and so mitigate some of the dangers.

There is a striking difference, too, in the design of turbines at present. One school favours high speeds and few wheels, which makes a short machine ; the other school prefers lower speeds with more stages, and so produce a larger machine. Which will survive ? A very

high thermodynamic efficiency has been obtained by each school, so it may prove that maintenance and operating results may be the deciding factor in influencing future progress. The obtained thermodynamic efficiencies of over 80 per cent. do not leave much room for improvement except by the use of higher temperatures and pressures.

The mercury vapour turbine developed by Mr. W. Emmot at Schenectady and operating at Hartford, Conn., is still another alternative which, however, has more claims for the betterment of existing plants than as forming a unit in a new large station, but it should be mentioned, as it may take a larger field than at present seems probable. The condenser in such generating units is a steam-boiler, and so arranged that steam may be delivered into the ordinary steam-header, capable of generating as much electricity on the old steam-turbine sets by the waste heat in which it has been formed, as the mercury has already generated in the mercury turbine. In other words, old boilers may be taken out and their place taken by mercury turbine units which will, without scrapping the old turbine plant, raise the station overall efficiency.

Mr. Kearton dealt with the theory here fully last November when I gave some particulars of the Hartford machine.* It will suffice to add that the machine is running regularly, as I heard from Hartford a few weeks ago, giving 1,500 kw. from the mercury turbine, and steam delivered into the station mains which produces another 2,000 kw. in the old turbines. The price of mercury is now 50 per cent. more than it was before the war. In that respect it is not unique. The cause for anxiety is the possible inadequacy of the supply. Although it is the first binary fluid system to be brought to such a stage of development, its success may have a stimulating influence on other combinations which will ease a mercury famine and produce another alternative than a synthetic mercury.

When considering translating the more efficient heat cycles into practice, we are restricted by the effect of temperature on the elastic limit of steel and other materials included in the design of the machines. The effect of high temperatures on the physical properties of steel has been investigated by Professor Lea, Dickenson and others, but little has been published on, or possibly done in exploring, the effect of temperature on the metal under continued stress, and, further, as to how far exposure of the metal to temperatures somewhat below what we know is quickly deleterious i in time harmful. Some light might be thrown on the latter point by users of oil stills, but so far I have not been able to get any such useful information. I hope the matter may be followed up by workers in that field. There must be material available, and sufficient operating particulars in respect of it, which could be profitably investigated.

Makers are willing to offer turbines and boilers for 1,200 lb. pressure, and say, 750 deg. F. steam temperature, but much more knowledge of what may happen is wanted to ensure a feeling of security to those who have to operate such a plant. The material of which the boilers are in future to be constructed is by no means settled. In the days of Lowmoor and good iron plates, little irregularities in working them up caused no anxiety, Steel brought other troubles, and the mistakes which have occurred, even in the best regulated families, have had serious importance. The higher pressures call for heavier scantlings or stronger material. There are limits to the thickness of plates which can be worked. Is the alternative to be sought in alloy steels, which are more delicate to handle and call for much more skilled care and close supervision in the shops than ordinary steels, or what line are we to work along? The pressures and temperatures proposed in connection with the new boilers now in hand open out lines upon which we have not yet travelled. Are the lines yet ready for use? As regards pressures, we can revive the "flash" boiler without any useful steam-drum capacity, but then we would lose the storage which is an undoubted benefit in itself, and we would also, due to the absence of proper disengaging surface, ensure the delivery of foam or "waterstuff" to the superheater, which is very undesirable. I think, therefore, "flash" boilers are not likely to become popular.

When considering the drum plates for the Trenton Channel boilers, with 30,400 sq. ft. water heating surface and 28 ft. by 48 in. drums, to work at 400 lb. pressure, nickel-steel and mild steel were both under review, the latter being preferred. The plates used are 2 in. thick. The boilers in this case are of the Stirling type. Similar plates are being used in boilers of the Babcock-Wilcox type with 15,000 sq. ft. heating surface to work at 600 lb. pressure.

The drums for the 1,200 lb. steam pressure Babcock-Wilcox boilers with 19,743 sq. ft. heating surface now in hand for the Boston Edison Company and elsewhere, are forged steel cylinders, 48 in. inside diameter, 56 in. outside diameter, and 34 ft. long. Mr. Cox, of the Midvale Company, Philadelphia, who are making the drums, lately stated that they are perhaps the largest hollow forgings ever made. The weight finished is 162,000 lb. The billet was cut from a 78-in. octagon ingot weighing 262,000 lb. It was stood on end and upset to about 96 in. in diameter, then had a 23-in. core removed with a hollow punch, was expanded to about 50 in. inside diameter, drawn on a mandrel to 45 in. inside and 58½ in. outside diameter, annealed, tested, machined inside and out, and after closing in the ends for manholes is to be re-annealed. That hardly sounds like boiler-making! Indeed, the manufacture of such drum forgings can only be undertaken by a few selected masters of their trade.

The alternative to the use of such huge masses of material to meet the new pressures and temperatures is either a radical alteration in the design of our steam generators or the use of alloy steels.

May we hope that our new grandchild "Ferrous Alloys Research" will produce a super-strong steel worthy of the occasion and of its parentage? About 1904 the Stirling Boiler Company made a four-drum boiler of 1,850 sq. ft. heating surface for 500 lb. pressure of nickel-steel plates, which I am informed is still at work. I believe a unique case. Could we contemplate the use of nickel, vanadium, or other alloy steels in ordinary boiler shops along with the ordinary output? I take it no, and this apart from the mere consideration of cost per ton of the raw material.

Professor Lea lately gave me an opportunity of seeing some of his work and methods, which makes me anxious for a report of it to the Institution, supplementing his paper in our 1922 Proceedings, so soon as he is free to contribute one to us. Meantime he allows me to say that he finds that a mild steel containing, let us say, 0·14 per cent. carbon, will at 400 deg. C., that is, 752 deg. F., if tested, break in one hour at a stress of from 25 to 30 tons per square inch. If, however, this steel is tested at a temperature of 400 deg. C. so as to determine the stress at which there is no continuous change of form, or, in other words, the stress, a slight increment of which will produce fracture in a very long time, then the critical stress is only about 14 tons per square inch, that is, if the working stress in a tube is 5 tons per square inch, the factor of safety is less than 3. Furthermore, if the temperature is raised to 500 deg. C. the critical stress in only about 4 tons per square inch.

It would appear, therefore, that in boiler work, as long as the temperatures are not more than 400 deg. C. there is an ample factor of safety, but if it is possible for the temperature to approximate to 500 deg. C., unless the working stress is very small, the factor of safety is small. Merely increasing the carbon content of the steel to, say, 0·32 per cent. carbon, does not increase the critical stresses very much at 400 deg. C. and 500 deg. C. respectively, as these are raised only to 16 tons and 6 tons per square inch respectively.

Certain alloys, however, containing large percentages of nickel have critical stresses at 500 deg. C. as high as 16 tons per square inch. The same alloy steel when tested so as to break in ten hours fractured at a final stress of 32 tons per square inch, as measured on the original area. When loaded gradually with a very slow rate of increment the specimen broke in 170 hours at 22 tons per square inch. A specimen of steel containing 0·35 per cent. carbon, 1·0 per cent. chromium and 1¼ per cent. nickel, tested at 525 deg. C., carried a stress of 25 tons per square inch before breaking in four hours. The same steel, however, when tested at the same temperature, broke at 7 tons per square inch in 1,060 hours. The critical stress for this steel at 525 deg. C. is about 6 tons per square inch.

When we consider the high degrees of technical skill and supervision entailed in the manufacture of parts constructed of such alloys, I think we must agree that we are not yet prepared to pay the price which must be asked for boilers made under such conditions, nor can we expect them to be turned out of an ordinary boiler shop. Meantime it would appear that the most important thing in connection with boiler work is to keep the temperature below some specified amount which it would appear for ordinary steels at the present time should be, in order to ensure a factor of safety, of at least 2, not more than 425 deg. C. It is interesting in connection with these matters, which are now so prominently before us, to note what circles we are running in, and how many inventions are born before their time.

Dr. Pole, late hon. secretary of the Institution of Civil Engineers, published a translation of a book by Dr. Ernst Alban, 1848, in which Alban records his use of steam at 1,000 lb. pressure. The engine kept perfectly tight but the hemp packing singed, and the boiler gave trouble at the soldered joints. I am wondering how soldered joints were made in those days, and am afraid we have lost the meaning in the translation from the original German. He quaintly adds that he does not like thick plates, especially when of cast iron, as they are more likely to crack by the action of the fire than thin plates. For his pipe work he used coned metal-to-metal joints. He found that by raising the grate level 6 in. he halved the work done by the boiler, "because the gases then came in contact with the surface of the boiler before they were perfectly consumed." Some people do not appreciate that yet! Professor Cotteril in 1890 recommended the heating of feed-water by steam from the intermediate cylinder of a triple-expansion engine, backing up Messrs. Weirs' recommendation in that line. Reheating was patented by Daniel Adamson and Leonard Cooper in 1852, in connection with compound engines. It is only now that we are beginning to appreciate the full value and importance of these things.

Fuel.—Another important question arises over fuel. If coal, and it is our chief fuel, how are we to burn it? It should be burnt smokelessly and must be burnt economically.

Our Institution was asked to attend a Conference at the Ministry of Health on the Report of Lord Newton's Committee. Our then President, Captain H. R. Sankey, R.E., was our spokesman, and offered the services of the Institution if called on. I do not know that any practical result followed; it is not apparent.

In larger establishments we have power and steam raising stations which handle all the different classes of coal, but the varieties which any one station will handle economically are limited, and so we often find ourselves restricted to coal of one particular class. It is just here where pulverised fuel, of which we have heard a great deal in the last few years, helps us. When burning coal pulverised, it is much easier to make such changes as are necessary to handle coals of different volatile content, or of varying ash content and fusing point, hence this system is being adopted in preference to burning lump coal where a continuity of supply of a given coal cannot be relied upon. The efficiency of the best mechanical stokers, when properly set and handled, is very high; indeed, there is very little difference between their performance and powdered fuel burning. It must be borne in mind, however, that although stoker efficiency may be slightly improved, there does not appear to be much room for real improvement; on the other hand, the use of powdered fuel under boilers is new, and while the thermal efficiency may be high, the cost of preparing the fuel and of constructing the furnace should be and is being greatly improved upon.

To what extent powdered coal is going to help us is very much "in the lap of the gods." The keenest boiler house engineers have taken it up as they know where they found the stoker and to what pitch of perfection they have brought it, and they, knowing how little difference there is between stoker and pulverised fuel firing at present, are of the opinion that they can improve on the latter as the result of practical operation and experience with it.

If you have stood, as I have, on the ash-dumping doors of a pulverised fuel furnace and looked clear up to the top steam-drum over 50 ft. above your head, you will agree with me that the furnaces under construction in five years' time will be something very different from the present church-like structures. Take another view and consider the height above ground level of such an arrangement, when, as often happens, you desire to run a railway wagon in under the boilers, how high up is the building needed to cover coal bins, &c., over the boilers? If steam turbines were still built with vertical shafts the boiler house building would not look so much like a high-explosive factory! Dryness of the coal, quality of the coal and fineness of grinding are points which are interrelated, and how far they are each interdependent has not yet been determined; further, the ability to adapt the arrangement to suit the conditions required for the combustion of a wide range of fuels has to be taken care of in the design.

When large boiler units are employed the number of instruments is not great in comparison with the work done. The use of large boiler units and large combustion chambers enables a very compact and convenient arrangement of boiler room to be adopted, and a high boiler efficiency to be obtained over a large range of duty. I mentioned hand regulation of the engines at Maiden Lane. I was reminded of it when I saw boilers similarly controlled by one man sitting in a stool handling about 40,000 kw. Dirty and unattractive boiler rooms should be a thing of the past. While coal-firing we cannot reach the comfort of oil-firing conditions, but we can approach it.

We know our Navy is dependent on oil, and that we could supply oil from our coal to meet its requirements, and we hear the American oil supply is fast running out. Whether we accept the dates for shortage and famine which have been proposed by U.S.A. experts is not so important as the absence of any decided steps to develop alternative supplies, here or there.

Sir George Beilby in his James Forrest lecture, 1921, and the Fuel Research Board Reports, tells us officially what we know unofficially, that engineers and chemists have developed low temperature carbonisation processes which will work, and we know that in the last few years much work and money has been put into such schemes, but none has yet published a record of a commercial success. Upon whom does the onus of taking the first practical step fall? It appeals to me as a national matter.

Mr. Henry Ford, after experimenting for some time at Huntington, West Virginia, is building a full-scale plant at his new works in Detroit, to treat 4,000 tons of his own coal a day on a bath of molten lead. It is admitted that there are a number of commercially unsolved problems to be developed, but the facilities of using the coke, gas, motor spirit, and tar all on his works, with Mr. Ford's boundless energy and persistence, with his financial ability to see through to a conclusion any scheme he takes in hand, makes one hopeful that real good may come from the venture.

While we have such practical proofs at hand as to the availability of gas, the oil and gas Holzwarth turbines are reported after successful tests as ready to come on the market. A 700-kw. gas and a 300-kw. oil turbine have already been run, following other experimental machines, and a 5,000-kw. gas turbine is practically completed ready for running. The trials have shown high thermal efficiencies, and that the average temperatures to which the turbine blades are subjected do not exceed those obtaining in a modern steam turbine. This is, indeed, welcome news if prolonged use will substantiate the shop runs which have been made. At any rate, the knowledge and experience in turbine construction which is available to-day is so far ahead of what was obtainable for very many years after the first steam turbines were running, that we may expect the development of gas turbines to be rapid. Personally, I feel convinced that in a short time we shall be seeing these things as well as the commercial utilisation of our lignite and other low-grade fuel stocks as accomplished facts.

* Proceedings, I.Mech.E., 1923, page 954.

THE INSTITUTE OF METALS.—The Journal of the Institute of Metals, vol. XXX, is now available and can be obtained at the Institute's offices, 36, Victoria-street, S.W. 1, at the price of 31*s.* 6*d.* net. The book opens with the May lecture delivered in 1923 by Dr. Rosenhain, on "The Inner Structure of Alloys." It further contains the papers read at the last autumn meeting at Manchester, with the full discussions. It has 838 pages, including the proceedings of that meeting, abstracts from the technical press, reviews and indexes. The book forms a valuable addition to the Institute's series.

POWDERED COAL: ITS PREPARATION AND UTILISATION.*

By R. JACKSON.

(*Concluded from page* 383.)

Storage Bins, Feeders and Burners.—From the pulverising mills the ground material is delivered carried in suspension on air, or by worm conveyors or elevators, to the powdered coal bin.

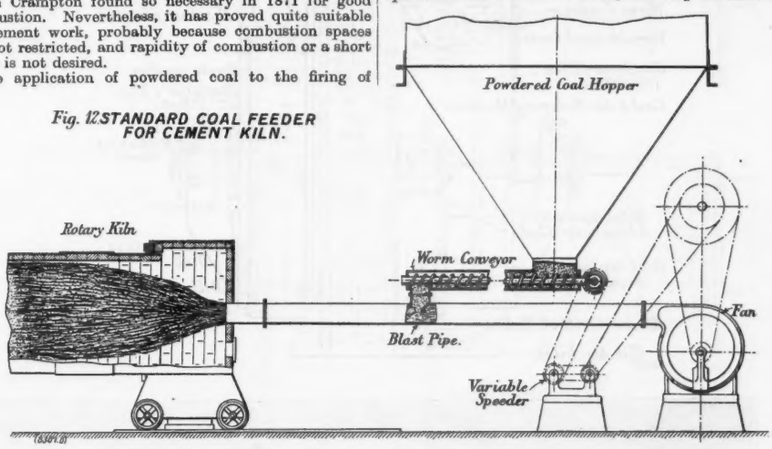
If delivered in suspension on air it is necessary to precipitate this dust, a most difficult matter, which is often accomplished by batteries of cyclone separators connected in series, the main vent passing back to the mill, and a small vent left open to atmosphere. The precipitated material is discharged into the storage bins ready for use. It is not intended to deal with details, but rather with principles.

The usual arrangement in the cement industry is that of a large storage hopper, holding 40 tons or more of powdered coal, at the base of which the worm conveyors (according to the number of kilns) are inserted, and which can be driven at variable speed. These worm conveyors transport the coal from the bin to the delivery pipe of the fan, where the air picks up the dust, and projects it into the kiln for burning as shown in Fig. 12, below.

Anyone who has studied the stratification of gas mixtures must be perfectly aware that such arrangement cannot provide that intimate mixture of coal and air which Crampton found so necessary in 1871 for good combustion. Nevertheless, it has proved quite suitable for cement work, probably because combustion spaces are not restricted, and rapidity of combustion or a short flame is not desired.

The application of powdered coal to the firing of

Fig. 12.—STANDARD COAL FEEDER FOR CEMENT KILN.



boilers rendered it necessary to obtain complete combustion in the minimum period of time, so that combustion chamber proportions could be kept within reasonable limits, and has led to the design of innumerable types of feeders, mixers, and burners, all with the avowed object of projecting an intimately mixed and combustible dust cloud into the furnace at low velocity and in the desired proportions.

The usual type of feeder consists of a long fine pitched worm conveyor, which is fixed on the base of the storage hopper, and is driven through gearing by a small variable-speed electric motor as shown in Fig. 13. The discharge end of the conveyor terminates in the fan blast pipe, and is here fitted with a distributor or equaliser, so as to obtain uniformity of feed. The powdered coal is thus entrained in the air stream, and, after passing through one or more mixers is discharged by the burner into the furnace for burning. Mixing is performed by turbulence or by creating a whirling motion, and thus breaking down any tendency to stratify. The amounts of coal can be precisely regulated, but difficulties sometimes occur caused by the coal bridging in the hoppers due to moisture, as powdered coal is exceedingly hygroscopic. The worms must be long and of fine pitch to preclude any possibility of flushing past the feeder, as the coal when dry and aerated is very lively and runs almost like water. A number of feeders may be affixed to the same hopper, one feeder commonly supplying one burner only.

It is possible to regulate these feeders, and consequently the rate of heat generation, from a distant switchboard, thus centralising the control.

Burners.—In order to prevent the possibility of premature ignition or back fires, it is usual to arrange that the coal dust and air are admitted in the correct proportions in the burner, from which they are projected at sufficient velocity to avoid eroding the mouth of the burner or furnace wall by the flames. Two types of burners are in common use, one in which the coal dust, mixed with primary air under fan pressure, induces secondary air through concentric nozzles to form a combustible mixture, and the other where the secondary air, in addition to the primary air, is delivered under fan pressure.

Some of these burners are set in batteries of two or more, according to the furnace, and others are designed to give wide angle low velocity effects, to obtain rapid combustion.

There are many individual types of burners, having limited or specialised application which time will not permit to deal with here.

When the boilers or furnaces are numerous or scattered, it is necessary to have some means of transporting the coal from the pulverising plant to the bins. The common method is undoubtedly the screw conveyor, but the air pressure system is finding great favour. The two systems most popular are the Fuller-Kinyon system and the Quigley. The former consists of a worm pump rotated in a long cylinder by an electric motor. The coal falls from the bin into the worm, and after being discharged at the end of the worm in a slightly compressed state meets a small jet of compressed air, which aerates and renders it so fluid that it can be propelled easily through long distances. The pressure used is up to 45 lb. per square inch for distances of 1,200 ft., and a 6-in. diameter pump will propel about 4 tons per hour this distance. Smaller pressures may be used for lesser distances.

The Quigley method consists of two or more bins of say, 8 tons capacity mounted on scales, one of which, may be filling while the other is emptying. From these bins the coal passes to blowing tanks, from which it is driven as pistons of coal alternating with pistons of compressed air. An operator is thus able to deliver a definite quantity of coal to any desired bin, by merely opening a valve. It is stated that 2,800 lb. of coal can be propelled 600 ft. through a 4-in. pipe in 1 minute, with air at a pressure of 15 lb. per square inch. The small amount of air entrained with the coal is allowed to escape through small dust arresters mounted on the storage bins. These conveying systems are usually operated from a central station, and very accurate and complete records of the amounts of coal delivered to the various furnaces may be obtained.

An alternative to these systems of bulk conveyance to bins is that of direct distribution of the coal when suspended in air, to the various furnaces, such as the Holbeck. The system may have circulating ring main or non-return main, according to conditions prevailing. In the former case the unused coal dust returns to the storage bins for redistribution. The direct system is best applied when furnaces are adjacent, as the cost of distribution is high when scattered—or when the use is very intermittent.

This rapid survey of the storage method of coal-dust preparation is intended to show by contrast the very narrow development which has taken place since its introduction, the most striking apparent developments being in the feeding and distribution of the coal. Certainly improvements have taken place in the design of dryers and pulverisers, but the fact remains that the mode of preparation is substantially the same as it was twenty years ago, needing a large and extensive plant entailing high capital expenditure, incurring the use of separate mill houses for preparation purposes, requiring a large operating staff and expensive repairs.

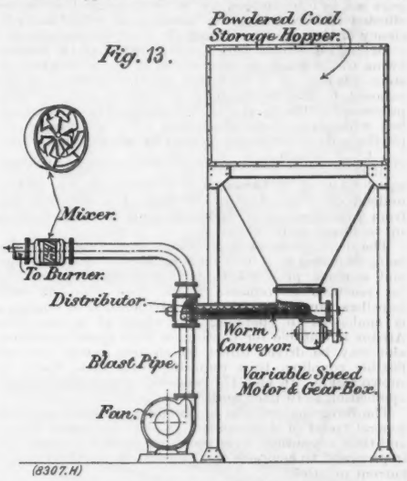
These facts preclude its use on any but a large scale, and have led to the development of several types of self-contained apparatus, termed unit pulverisers, which are particularly suitable for European conditions, and are steadily growing in public favour. There are many reasons why it should be so. The capital cost of such unit plant is low, and since it occupies little floor space and requires no skilled labour for its successful operation, two charges incidental to the storage system can be practically eliminated. The power required expressed in horse-power per ton is not appreciably greater than for the storage system, in fact, is less with the large unit machine than with storage plants of similar capacity, and when it is considered that a most careful check can be kept on the former, and that it has none of the complications or elaborations of the latter, the actual advantage will undoubtedly be in favour of the unit system. The dust nuisance is entirely eliminated, as the whole of the pulverising process takes place on the suction side of the machine, and since there is no storage of powdered coal, there is no risk of dust fires or spontaneous combustion. No extensive or elaborate conveyor or transport methods are entailed, as the unit pulveriser can be placed directly against the furnace to be fired, and the attention required, providing the raw coal be fed mechanically, is purely nominal.

There are several types of unit machines made in this country, perhaps one of the oldest being the Bettington pulveriser, which was developed in conjunction with the well-known Bettington boiler. This machine pulverises by impact or beating, and consists of mild-steel shell, forming a fan casing in which the pulverising liners or saw-toothed bars are arranged concentrically with the motor. The whole is supported on heavy cast-iron side frames or pedestals, which also carry the bearing brackets for the rotor shaft and feeding mechanism. The rotor consists of two mild steel discs, firmly secured to a hub and to the rotor shaft, and the beaters are secured between these discs at their periphery, revolving in a path concentric with and adjacent to the liner bars.

On either side of the rotor discs fan elements are secured, which draw air into the pulveriser and deliver it mixed with coal dust from the discharge branch of the machine. The coal is fed into the pulverising zone by a worm conveyor, whose speed can be varied to give the requisite output. When in operation, the fan forces the coal to the liner, where it comes in contact with the revolving beaters, the finer particles being carried away in suspension on the air stream, to a separator or elutriation chamber, where the coarse particles are precipitated and return again to the pulverising zone. Hot air may be admitted to the machine to facilitate drying, the temperature being about 300 deg. F., and the moisture content of the coal may run up to 10 per cent. Since the drying takes place in a closed circuit no loss of hydrocarbons takes place, which is an advance on the separate method of drying. The upper part of the casing is hinged, so that the renewal of beaters, &c., may be easily done when necessary.

Another type of unit machine is the turbo pulveriser,

Fig. 13.



which consists of a cylindrically shaped housing, the upper half of which is hinged for purpose of inspection or repair. This housing is divided into three or more compartments forming pulverising chambers, which are fitted with renewable liners, access from one compartment to the next being provided by an aperture of suitable dimensions. The feeding mechanism is located at one end and the rate at which the coal is admitted to the machine can be regulated as desired. The pulverising medium consists of a number of rotors equal to the number of compartments, which carry a number of beaters on the periphery, the whole being mounted on a common shaft.

A fan, which is also mounted on the shaft, is situate at the opposite end to the feeding gear in a special compartment, and its purpose is to induce a draught of air through the pulveriser, which carries in suspension the finer particles from one compartment to another.

The draught can be regulated by opening an air inlet adjacent to the fan, thus short circuiting the pulverising zone, the fineness of the product being regulated in this manner. The rotor is supported on external bearings, and like the Bettington machine can be arranged for direct motor drive. The size of coal usually dealt with is about $\frac{3}{4}$ in. cube, containing about 5 per cent. moisture.

The Vickers Griffin mill differs from the two pulverizers previously described, and is a slow-speed machine running from 200–250 r.p.m. This may be called a two-stage machine, the coal being fed from an automatic feeder into the first stage, where it is broken down or granulated by beater arms secured to the shaft. From this stage it is drawn into the second or final pulveriser, which consists of a grinding ring with balls, the latter rotating with the shaft, thus reducing the coal to powder by centrifugal pressure between ball and ring. The fine product is drawn away by a fan into a separating chamber, from whence the coarse particles gravitate back to the ball mill for further reduction, the fine particles remaining in suspension being delivered to the furnace for burning. The degree of fineness of the product may also be regulated by controlling the amount of air passing through the machine.

One of the most recent developments in unit pulverizers is the Atritor, so called because it pulverises by attrition (*i.e.*, to rub down). This machine, which is illustrated in Figs. 14 and 15, page 416, combines all the functions of a modern storage plant and incorporates: (*a*) coal feeding mechanism, (*b*) metal separators, (*c*) coal dryer, (*d*) pulveriser, (*e*) blower or ejector. The coal which may have a size up to $\frac{3}{4}$ in. cube, is fed into the hopper and is delivered by a short worm conveyor, running at variable speed, through a discharge port, when it descends into the metal separator. Here the coal is intercepted by a current of cold air (drawn into

* Abstract of paper read before the Midland Branch of the Institution of Mechanical Engineers at Coventry on February 7.

the machine by the fan), which is travelling at a velocity just sufficient to lift the coal into the pulverising zone. This arrangement is most sensitive and will eliminate small stones, ferrous and non-ferrous metals, which fall down the chute to the outside of the machine. The difference in specific gravity of coal and common metals is considerable, coal varying from 1·3 to 1·7, and iron 7·8, brass 8·1, copper 8·6, aluminium 2·56. It will be appreciated that such separator is more efficient than a magnetic separator, since the latter will only deal with magnetic materials and then only when energised. A supply of hot air at a temperature about 450 deg. F. is drawn under the base of the machine into the pulverising zone, and its purpose is to dry the coal during pulverisation.

Pulverising is performed by attrition and not by impact or beating, and the pulveriser consists of a rotating steel disc having pegs or impellers mounted on either face. The function of these impellers is to set up air vortices or turbulence, and the coal particles according to their mass, become entrained on the air currents which are travelling at sufficiently high velocity to suspend them. The attrition caused by the heavily charged coal-air streams travelling at widely varying velocities rapidly breaks down the coal. The fan stream is slowly passing through the mill and carries the finest particles to a rejector, which eliminates all of coarse degree and accepts only those of required fineness which pass to the fan and are delivered to the furnace for burning. The stationary pegs act as interrupters, and while pulverisation can be effected without them, they increase the output and efficiency of the mill by assisting the attrition phenomena.

Drying takes place during pulverisation, and is possible owing to the small amount of coal in the mill at any instant (2 lbs. or 3 lbs.) and the tremendous surface exposed to the drying influence of the hot air when pulverised. This point is not sufficiently understood, but when it is considered that 1 lb. of average coal (50 lbs. cubic foot) would contain 34,500 million particles of $\frac{1}{1000}$ in. cube, whose surface when spread out would equal 1,440 sq. ft. the method of drying the coal will be understood. The Atritor will deal with coal of a size from $\frac{3}{4}$ in. downwards, and containing moisture content up to 20 per cent.

The design is exceedingly compact, the rotor and fan being mounted in a steel shaft running in ball bearings, and a crane provided to facilitate rapid dismantling for renewals or repairs. Spare discs complete with impellers can be provided and the method of changing is analogous to changing the wheel of a car. The Atritor is suitable for continuous high-speed operation, and may be driven direct by electric motor, through flexible coupling, thus requiring little floor space, as shown in Figs. 16 and 17, page 417, which illustrate its application to furnace work.

The foregoing remarks are intended to emphasise the general trend of development in unit pulveriser design and their advantages over the usual storage systems. It is proposed to compare the two system on the basis of current practice.

(1) *Efficiency.*—This is rather difficult to define, but the power absorbed by the two systems when pulverising to the same degree of fineness may be compared. The figures recently quoted by Mr. Brownlie before the Institution of Electrical Engineers indicate that the average power consumption at the Lakeside Station, Milwaukee, spread over a four months period is 24·1 kw. hours per ton of coal = 32·3 h.p. per ton, eight pulverisers of Raymond and Fuller types each having 6 tons capacity per hour, being installed. This result would be improved upon by a unit pulveriser of only 2 tons capacity, which would require approximately 30 h.p. per ton of coal, as shown by the curves in Fig. 18, page 417. The central plant being installed at Vitry is estimated to absorb 19½ kw. hours or 26·2 h.p. per ton of coal pulverised. In this installation vertical waste heat dryers are proposed to effect the lower power consumption. In general the power absorbed by the two systems of small capacity will compare in favour of the unit machine, the storage plant having the advantage when operated on large outputs. The storage system, being much more expensive initially than the unit system, the interest and depreciation charges will be considerably greater, the comparison being approximately as shown in Fig. 19.

Renewal Costs.—The Lakeside figures quoted by Mr. Brownlie show an average renewal cost over a 15 months period of 1·17d. per ton of coal ground. The analysis given of such repairs over the pulverising plant only, and it is conceivable that the elevators, dryers, conveyors, fans, feeders, &c., will eventually require some replacements and that labour is entailed in the process. Therefore the corrected figure will undoubtedly be much higher. The cost of replacements only, for unit pulverisers will be slightly in excess of 1*d.* per ton of coal pulverised.

Labour Costs.—The Lakeside figures show that the total cost of labour in the pulverising house is about 4*d.* per ton, excluding the labour required for unloading cars. With a unit installation, this can be eliminated as the attention required is negligible, and can be incorporated in the fireman's duties.

Reliability.—The reliability of the storage system is often emphasized, but it is far from infallable and repairs are necessary and oftimes lengthy. By means of surplus elevator, dryer and pulveriser capacity it is possible to carry a large amount of powdered coal in storage, thus providing against eventualities. When continuity of operation is *sine qua non*, similar surplus capacity in the form of spare machines should be provided when unit machines are installed. When operated under correct service conditions, the unit machine is reliable, and can be trusted to give excellent service.

Some objections have been made against the high running speeds of unit pulverisers. Similar objections have been raised against all high-speed machinery, *i.e.*, turbines, electrical machinery, petrol motor-pump, fans, &c., &c., yet these have all survived the stern test of time to discomfort the pessimist. Other objectors have pointed out the reduced efficiency of unit pulveriser when operating on light load. This is not peculiar to the unit pulveriser but applies to all pulverisers, since

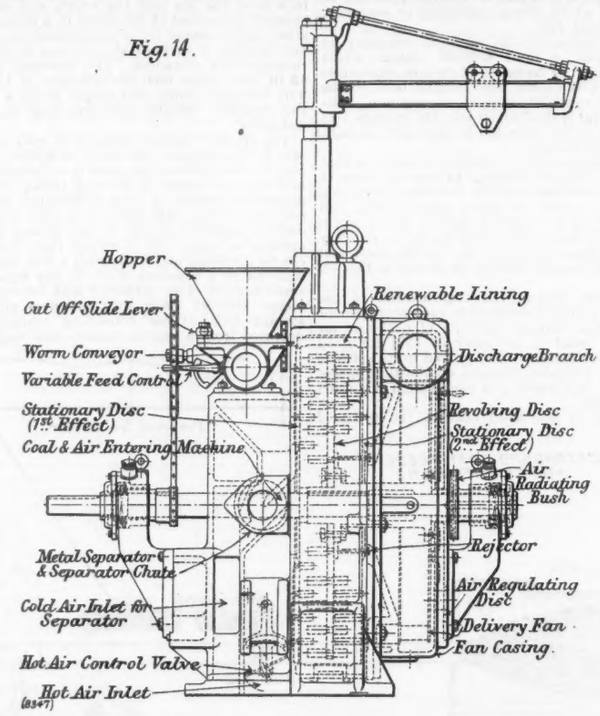


Fig. 14.

FIG. 15. MOTOR-DRIVEN ATRITOR.

ciency and labour, renewal and operating costs. The maintenance or running costs such as lubrication and sundries are overwhelmingly in its favour, and the capital and depreciation figures only become comparable when storage plants are of large capacity. It is admitted that the largest unit machine made at the present time could not be applied singly to boilers exceeding 40,000 lbs. to 50,000 lbs. evaporation, but larger machines when they are operated at maximum pulverising capacity the initial power required to drive and pulverise may then be expressed as the minimum.

The storage system is enabled by virtue of storage to run the pulverising plant at maximum capacity, the irregularities in requirements being compensated by the storage bins and feeds. The unit machines while very efficient at maximum capacity is not most inefficient when operated at lower ratings, as a considerable reduction in power may be observed.

Conclusions.—It has been shown that the unit machine compares favourably with the storage system for efficiency and labour, renewal and operating costs. The maintenance or running costs such as lubrication and sundries are overwhelmingly in its favour, and the capital and depreciation figures only become comparable when storage plants are of large capacity. It is admitted that the largest unit machine made at the present time could not be applied singly to boilers exceeding 40,000 lbs. to 50,000 lbs. evaporation, but larger machines are contemplated. When the requirements are extremely large the storage system will at the present time show some advantages, but for installations of moderate size the unit pulveriser is most suitable. It is significant that prominent engineers in U.S.A. and Canada are showing marked interest in unit pulveriser progress in this country, and if the production of larger sizes be found practicable there is no doubt that this application will be universal.

Experiments which have been made to reduce the power taken by pulverisers, have led to the use of coarser pulverisation, and for boiler firing the standard

usually adopted in U.S.A. is 90 per cent. through the 100 mesh screen and 65 per cent. through the 200-mesh screen (Lakeside) for bituminous coal.

It is surprising what a large number of people refer to the percentage of coal passing through a certain screen without knowing what it implies. Obviously it is not the screen that determines the fineness of the product, but rather the size of aperture in the screen. Two types of screens or sieves are used in this country, one being the I.M.M. and the other the B.S. cement screen, and much controversy has raged regarding their respective merits. The size of aperture in the former is equal to the thickness of the wire, whereas with the B.S. cement screen the aperture is equal to twice the wire

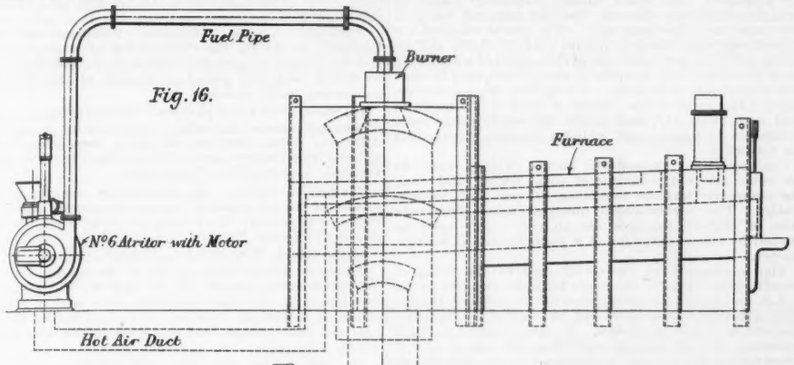


Fig. 16.

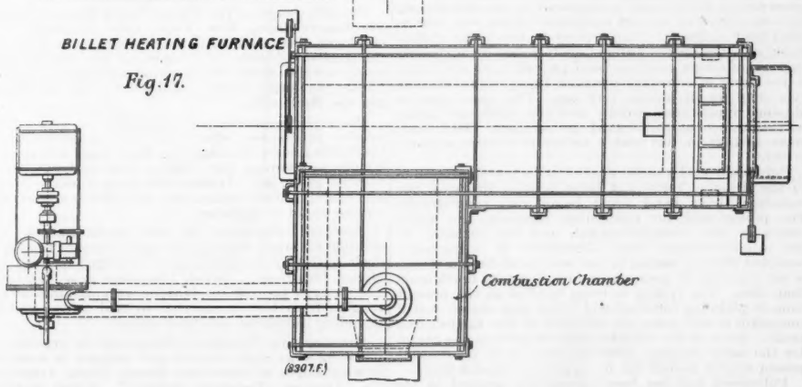
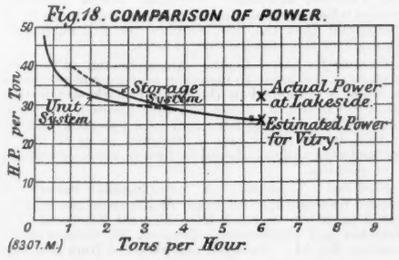


Fig. 17.



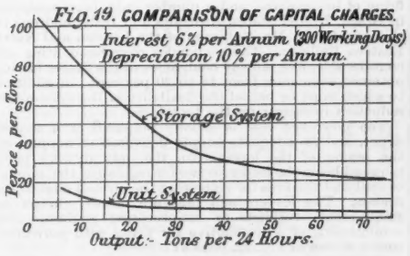


Fig. 19. COMPARISON OF CAPITAL CHARGES.
Interest 6% per Annum (300 Working Days)
Depreciation 10% per Annum.
Pence per Ton.
Storage System
Unit System
Output :- Tons per 24 Hours.

coal may be totally consumed before reaching the tubes or water-cooled surfaces. As the effect of hot gases travelling at high velocities is most destructive to refractories, it has been found that critical velocities exist and it is advisable to reduce the gas speeds below such points. Combustion chambers are therefore designed to meet these conditions, having regard to the free burning characteristics of the coal.

In general it may be stated that bituminous coal having volatile contents of 30–35 per cent. burn in the shortest period of time, and theoretically require smaller combustion chambers than semi-bituminous, carbonaceous or anthracite coals.

The fineness of product required for complete combustion will depend upon the particular application under review. In the cement industry, the fineness specified is 95 per cent. through 100^2 B.S. cement screen, and 85 per cent. through 180^2 B.S. cement screen, and the standard is preferred finer rather than coarser. For metallurgical purposes it is sometimes advisable to pulverise even finer, depending on the type of furnace to be fired and the class of coal employed.

When burning bituminous coal under boilers, the desirable degree of fineness will depend somewhat on the percentages of volatiles or ash in the coal. From the author's experience, when burning coals containing 32 per cent. volatile and 25 per cent. ash, the best combustion conditions are attained when 94–95 per cent. passes through the 100^2 B.S. screen and 80 to 85 per cent. through the 180^2 B.S. screen.

On the other hand, when burning high grade coals combustion has been quite good with fineness of 80 per cent. through 100^2 B.S. screen and 60 per cent. through the 180^2 B.S. screen. The usual method in the U.S.A. is to use good run of mine coal containing 10–15 per cent. ash, and the degree of pulverisation is 90 per cent. through the 100^2 screen. As a general rule it may be stated that coals high in ash or low in volatile matter should be pulverised finer than low ash or high volatile bituminous coals. A more important point than the production of superfine dust, is that of eliminating the coarse particles having a size of 0·008 in. cube or over, and which are often termed "nibs" in the cement industry. The burning of such coarse coal is very undesirable and causes an accumulation of burning or partly burned ash on the walls and floor of the chamber and slagging on the boiler tubes.

It will be obvious that the largest particles permissible will be governed by the velocity of the gases required to sustain them, and the period of travel allowed before reaching the tubes to ensure complete combustion. Such elimination is performed with varying success by installing large separating chambers in conjunction with

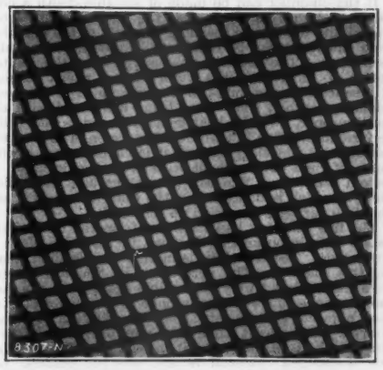


FIG. 20. I.M.M. SCREEN (ENLARGED).

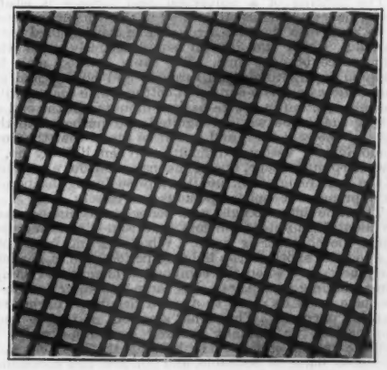
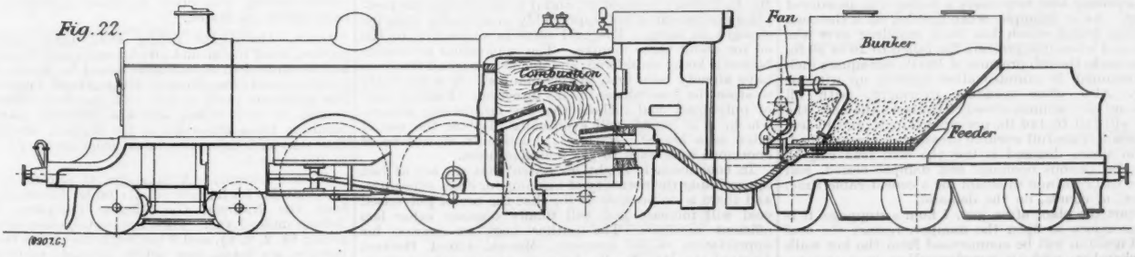


FIG. 21. STANDARD CEMENT SCREEN (ENLARGED)



thickness. It might be inferred from this that the I.M.M. sieve would give the finest grading, but it is remarkable that the cement sieve is much superior, showing greater constancy and uniformity. The author's company have therefore adopted the cement standard sieve as the basis of fineness. Microphotographs of the two types of screen, taken to the same scale for comparison are shown in Figs. 20 and 21.

The burning of coal in pulverised form offers many advantages over other methods, the combustion efficiency being perfect, as the coal is delivered into the furnace in a fine state of division intimately mixed with air, forming a highly inflammable dust cloud. Combustion takes place almost instantaneously while the coal is in suspension, and as the burning gases are moving forward it is necessary to allow a suitable time period so that the pulverisers, so that the coarse particles will gravitate back to the pulveriser. The methods adopted for dealing with the resultant ash of combustion will depend on the fusion characteristics of the ash, whether the plant operates intermittently or continuously and on the space available for combustion chambers. This particularly concerns boiler practice, as in the cement industry the ash assists in the production of cement and in metallurgical processes, is invariably run off in the form of slag except when used for low temperature work such as reheating, &c., when the ash may be handled as for boilers.

It is usually most difficult when considering the conversion of existing boilers fired by hand or stokers to obtain the combustion chamber proportions desirable.

The importance and advantage of high boiler settings

and large combustion chambers has not been sufficiently appreciated until recently with the result that when fired by pulverised coal it is necessary either to raise the boiler or excavate to a suitable depth. Both these proposals have their limitations, due to the height of existing boiler-house buildings and the nature of the subsoil, with the result that the combustion chamber design must ofttimes be modified to meet the peculiar conditions.

When the ash is highly refractory (fusing at 1,450 deg. C.) it will usually be precipitated in the combustion chamber in the dry state and will present no difficulties to removal. If the plant be working intermittently, say, on ordinary day load, and the fusion point of the ash be 1,300 deg. C. to 1,350 deg. C., the ash can be easily handled.

Slagging occurs chiefly when boilers are operated at high ratings continuously, and when the fusion temperature of the ash is between 1,200 deg. C. and 1,350 deg. C. It is accentuated also by shallow or restricted combustion chambers. Under these conditions it is usual in this country to provide means for its removal as slag, and if it is allowed to drip it soon hardens or globulises, and is easily withdrawn.

If the chamber can be made of suitable depth a cold zone can be arranged, so that the falling ash becomes chilled and dry before reaching the base of the chamber from whence it can be raked out in powdered or nodulised form. The method now adopted in the United States of America is the water screen, which consists of a series of water tubes in the lower part of the combustion chamber, such tubes being connected with the boiler proper, and the heat generated assists the boiler performance. The function of this screen is to cool the ash and prevent slagging, and it is claimed that a wide range of fuels can be dealt with at high efficiency. A certain amount of fine ash passes through the boiler, some of which is deposited in the flues and passes, and about 20 per cent. is carried up the stack.

The fine ash may be withdrawn from the base of the passes or from pockets in the flues, by a suction plant or air ejector. The use of air is more desirable than steam for this purpose. The percentage of fine ash ejected from the stack is barely perceptible against the sky, and though the author's company have several acres of glass roofs adjacent to a low stack, no precipitation has been noticed. This point compares most favourably with other methods of firing and it must be emphasised that this discharged material is not soot or cinders, but incombustible superfine material, which is carried in suspension, for considerable distances and commits no local nuisance. It is generally assumed that it stays in suspension until precipitated by moisture.

The lighting of a pulverised coal furnace is easily performed, and the usual method in the cement industry is to push into the kiln a number of bags soaked with paraffin, which are ignited simultaneously with the admittance of coal dust. The same method may be adopted for lighting small furnaces and boilers, and all that is necessary is a supply of cotton waste soaked with paraffin inserted in a wire basket, mounted in the end of a long rod. The waste is ignited and pushed into the path of the coal dust, and it will be found that the dust cloud ignites without difficulty. When lighting up, a few sharp puffs occur, due to the instantaneous expansion of the gases on ignition, and it is unwise during this period to approach the boiler openings too closely.

The time taken to light up a boiler in this manner may be about 15 minutes from cold, and from 5 to 10 minutes when the chamber is warm. When starting from cold a wood fire shortens the lighting period, and is particularly necessary when the combustion chamber is damp, after building or repairs. For large boilers or furnaces, recourse must be made to a wood fire or oil burner for lighting purposes. This is not a serious matter, as such applications are usually worked continuously for a definite period of time. In lighting the dust cloud, a luminous flame is desirable, and ignition will commence much quicker if this point is realised. After ignition, the flame will soon become stabilised and the required amount of coal may them be admitted and the necessary air adjustments made.

It is surprising how responsive a boiler is to powdered coal firing. As an example, when lighting up a Babcock and Wilcox boiler which has been standing over the week-end and where the pressure has fallen to 20 or 30 lb. per square inch, the full pressure of 160 lb. per square inch can be obtained 20 minutes after lighting up without difficulty. Also after standing overnight, with all dampers and air openings closed to conserve the heat, the pressure will fall to 140 lb. per square inch, and in less than 10 minutes the full working pressure can be attained. When the steam demand is low the coal feed can be stopped, the various openings and damper closed, and the boiler will continue to steam for a considerable time, depending, of course, on the demand.

To restart the plant after, say, 1 hour's stoppage, it is merely necessary to open the damper, restart the coal feed, and ignition will be commenced from the hot walls of the chamber, without supplementing in any way. The combustion efficiency is excellent, as the amounts of air and coal admitted are under precise control, and the CO_2 content in the flue gases can be maintained at 16 per cent. or higher if desired, without producing CO. The ash deposited in the combustion chamber shows but a trace of carbon. Very small percentages of carbon are found in the ash deposited in the passes and flues, and such losses are a minimum.

Extremely high boiler efficiencies can be obtained by the use of powdered coal, and the tests made by Kreisinger and Blizzard on the Lakeside plant showed an average efficiency of boiler, superheater and economiser, taken from 26 tests, of 87·6 per cent., and these results have been duplicated on many other plants. Further, the rapid progress which is being made in this direction should be sufficient proof to convert the most hardened disbeliever to this process.

A boiler fired by pulverised fuel is most fascinating to watch. The steadiness of the flame, the ease of regulation and instantaneous response of the boiler to meet varying conditions, the uniform chamber temperature, causing no hogging or bulging of tubes by local heating, the constancy of flue gas analysis, and entire absence of smoke, the elimination of moving parts in the furnace, and general simplicity of operation, all combine to make this application most commendable, and one which will undoubtedly grow.

Another feature in its favour is that high stacks or powerful draught fans are unnecessary, since boilers fired by powdered coal work under practically balanced draught conditions, the only draught required being to overcome the boiler resistance. The power required for pulverising when using a normal coal of 12,600 B.T.U. per lb. will be about 2 per cent. of the output of a moderate sized boiler, and will compare in many cases very favourably with stoker or oil firing. The system offers, however, many advantages in the variety of coals it is possible to deal with efficiently, and covers the whole range from anthracite to lignite, and includes washery slurry, and pit refuse.

Coal has been successfully burned having over 40 per cent. ash and mixtures of coke breeze and coal, the composite mixture averaging 10 per cent. volatile matter. The carbonaceous material taken from the flues of oil-fired furnaces can in very many cases be burned by the introduction of a small amount of volatile matter.

The application of pulverised coal to the firing of metallurgical furnaces has made far more progress in the U.S.A. and on the Continent than in this country, though some astounding economies can be effected by its introduction in many processes. In the copper-smelting industries of U.S., Canada and Chile, the use of oil and grate fires is being steadily displaced by powdered coal, the latter showing savings exceeding 25 per cent. above hand-fired methods. The process is also being extensively adopted for the firing of air furnaces for malleable iron manufacture and has been proved most successful in the firing of annealing ovens, it being estimated that over 300 are in present day use. The heats can be obtained much more rapidly and the ovens can easily be maintained at the desired temperature. There are great savings in fuel and a better and more uniform product.

Pulverised coal can be applied with excellent results to the firing of forge and billet heating furnaces, the economies over hand firing being very considerable. For piling, and for continuous furnaces, the application is very straightforward, and the furnaces do not usually require much alteration. It is generally accepted that the saving in fuel over hand-fired methods is not less than 25 per cent. and is often very much more than this. The system is being applied at the present time to puddling furnaces, and it has been stated that if successful it will mean the salvation of the English iron trade. Since it has already been adopted in the States for the same purpose, there appears to be no possible reason why it should not be equally successful here.

Pulverised fuel has been successfully applied to the firing of locomotives, and a number have been equipped in Brazil, United States, Australia and Italy, and one in this country by Mr. Robinson of the London and North Eastern Railway. The economies over hand firing are considerable, five railway companies in the States having obtained economies from 18 to 20 per cent., in addition to which must be placed the flexibility of the system and reduction in labour on the footplate.

The powdered coal is usually prepared at a central depot, and an adequate supply delivered to hoppers on the tender of the locomotive, the only moving parts required being the feeder screws for regulating the amount of coal and the fans for delivering the air and coal to the firebox. The feeders and fans are usually driven by small steam turbines or reciprocating engines. The arrangement of a locomotive for firing with pulverised coal is shown in Fig. 22, page 417.

Mixtures of powdered coal and oil have been tried on Mr. Robinson's locomotive, and it is stated that the footplate equipment is not appreciably more costly than for straight oil firing. The coal stays in suspension in the oil for about three months. The application to marine boilers is being considered, and one or two small steamers have already been fired in this manner. It is too early to state the possibilities in this direction. Further uses of pulverised coal include the dry briquetting process, which, it is hoped, will eventually displace the use of pitch as a binder. If this is practicable, it will be of enormous assistance to gas manufacturers.

In conclusion it might be stated that we are at last appreciating the necessity of burning our coals efficiently, and there is no possible doubt that the use of pulverised coal will increase and will finally displace other less efficient methods. The author begs to express his appreciation to his company, Messrs. Alfred Herbert Limited, to Mr. P. V. Vernon, and to the various members of his staff who have contributed to the preparation of this paper.

DISTINCTION AWARDED AN AMERICAN ENGINEER.—Mr. E. F. W. Alexanderson, consulting engineer of the General Electric Company and chief consulting engineer of the Radio Corporation of America, has been awarded the Order of the Polonia Restituta, by the Polish Government, in recognition of his services in connection with the building of Poland's new radio station near Warsaw. This station is the first in Europe to make use of the Alexanderson high frequency alternator now used in all Radio Corporation stations for transoceanic work.

CATALOGUES.

Tanks.—A list of steel tanks for the storage of oil, water, &c., and of high-pressure tanks, has come to hand from Messrs. W. J. Fraser and Co., Limited, Dagenham, Essex.

Ball Bearings.—The Formo Manufacturing Company, Limited, 67, Bunhill-row, London, E.C. 1, have issued a pamphlet explaining a formula for calculating the size of ball bearings required for any given load.

Chemical Plant.—A sheet of illustrations of machines for evaporating, filtering, pressing, drying, mixing, refining and other processes used in chemical works is to hand from Messrs. Manlove, Alliott and Co., Limited, Nottingham.

Pyrometers.—Messrs. Siemens Brothers and Co., Limited, Woolwich, have forwarded us a catalogue of thermo-electric pyrometers, temperature indicators and recorders, and also giving particulars of the necessary connecting leads, switches, &c.

Oil Storage.—A small pamphlet relating to tanks, pumps measuring pumps, and other appliances for storing and delivering petrol, paraffin, oil, paint, turpentine, &c., is to hand from the Dowson and Mason Gas Plant Company, Limited, Levenshulme, Manchester.

Mechanical Stoker.—An interesting account of the results of the adoption of Bennis chain-grate stokers at Croydon Electricity Works is given in an 8-page booklet issued by Messrs. Edward Bennis and Co., Limited, 28, Victoria-street, Westminster, London, S.W. 1.

Electrical Plant.—Messrs. W. C. Mountain, Son and Wood (formerly Messrs. W. C. and K. A. Mountain), Sun-buildings, Newcastle-on-Tyne, have sent us a list of electrical and steam installations carried out by them in coal and other mines, iron and steel works, docks, shipyards, &c.

Pressure Gauges.—The United States Gauge Company, 14, Beaver-street, New York, have forwarded us a catalogue illustrating a full range of gauges for measuring the pressure of steam, oil, water, air, &c., and including many special forms for testing and other purposes. Clocks, revolution counters, and other similar instruments are also dealt with.

Power Transmission.—A handbook on power-transmission accessories, which has been issued by Messrs. Crofts (Engineers), Limited, Bradford, deals with shafting, couplings, bearings, belt pulleys, rope pulleys, clutches, toothed gears, &c. It describes many varieties of each and contains much explanatory and tabular matter which will be useful to engineers.

Furnaces.—Furnaces of the forced-draught type suitable for steam raising and other forms of heating are dealt with in a supplementary catalogue received from Messrs. Meldrums, Limited, Timperley, near Manchester. The designs provide for burning various kinds of fuel, ranging from best steam coal to coal refuse, and also including industrial and town refuse.

Saw-Grinding Machines.—Machinery for grinding and polishing saws, both circular and straight, is dealt with in a catalogue to hand from Messrs. David Ashton and Co., Limited, Neepsend, Sheffield. Seven machines, some of which are made in several sizes, are listed, and we understand that the firm supplies the full equipment required for the manufacture of saws.

Fastener for Ships' Lights.—An application of the cam in place of the screw to fastening scuttles and portlights on ships is embodied in the Stone-Pollock scuttle clip, made by Messrs. J. Stone and Co., Limited, Deptford, London, S.E. 14, who have sent us a pamphlet relating to this device. The cam is designed so as to give a quick-closing action followed by firm pressure against the joint packing.

Electrical Apparatus.—A considerable variety of electric fires suitable for office or domestic use is illustrated in a list to hand from General Electrical Construction and Maintenance, Limited, 35, Cannon-street, London, E.C. 4. We have also received from this firm a number of leaflets dealing with lighting, cooking, bath-water heating, and other electrical apparatus. In all cases prices are stated.

Grabs.—Grabs for lifting coal, coke, sand, ores, pyrites, road metal and similar materials are described and illustrated in a catalogue issued by Messrs. William Goodacre and Sons, Limited, Russell-road, London, E. 16. The grabs are made to act with one, two, three or four chains, or wire ropes, and are variously adapted for handling loose materials or for digging, dredging, &c. The standard capacities range from about 20 cubic ft. to 100 cubic ft.

Electric Lighting.—A catalogue of electric generating sets, suitable for large or small country houses, is to hand from the National Gas Engine Company, Limited, Ashton-under-Lyne. Five horizontal chain-driven sets giving 1¼, 2, 3, 4½, and 6 kw. with the engine running on paraffin are listed, but petrol, alcohol, suction gas or town gas may be used in the engines with slightly different outputs. Two vertical direct-coupled sets of 3½ kw. and 6 kw. are also made for use where the floor space is very limited.

Electric Winding Gear for Collieries.—A number of sectional catalogues relating to electric winding gear for collieries, &c., have been issued in one binding by the Metropolitan Vickers Electrical Company, Limited, Trafford-park, Manchester. The sections include general notes, notes on ropes, mechanical arrangements, and control gear and a further section on switch-gear is in course of preparation. There are several excellent illustrations of winding plant installed by the firm and a list of such plants in South Africa, India, and Spain, as well as in many of the coalfields of this country.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

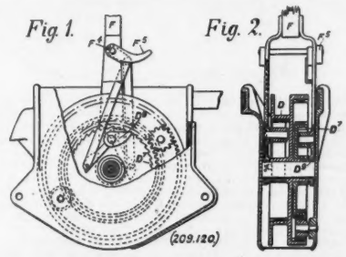
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

AGRICULTURAL APPLIANCES.

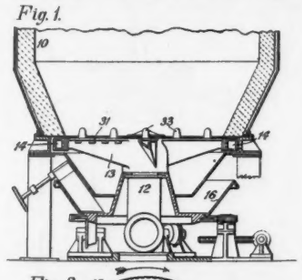
209,120. H. Mote, Westminster, London. Propelling Manually-Operated Agricultural Implements. (7 *Figs.*) July 3, 1922.—The invention relates to propelling mechanism for manually-operated agricultural implements of the type which is operated by a hand actuated rocking lever that carries a driving pawl for engaging with a ratchet wheel forming part of the mechanism which causes the implement to be moved forward to perform the desired work when the lever is angularly moved or rocked. According to one feature of the invention, the hand-actuating rocking lever F is provided with a catch device F^5 which, when the lever is depressed, enables the latter to be locked to the frame of the implement and also serves to move and maintain the driving pawl D^9 on, or associated with, the lever F out of engagement with



the ratchet wheel D^7, for the purpose of enabling the implement to be freely moved or drawn along without the propelling mechanism being operated. For example, in the case of an implement having propelling mechanism which comprises a rotatable drum D for winding up a cable, the implement after having been moved forward so that the cable is fully wound on to the drum can be pulled or moved in a rearward direction on its front wheels when the rocking lever F is locked to the frame by lifting the locked lever and the rear part of the implement during which rearward movement the drum D is free to rotate, owing to the driving pawl D^9 being held out of engagement with the ratchet wheel, so that the cable can be unwound as the implement is pulled in the rearward direction. (*Accepted January* 16, 1924.)

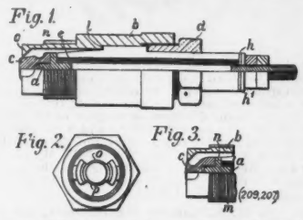
GAS ENGINES, PRODUCERS, HOLDERS, &c.

209,211. G. H. Bentley, Westminster, London, and E. G. Appleby, Westminster, London. Gas Producers. (7 *Figs.*) October 13, 1922.—The gas producer comprises a fixed shell 10, preferably circular in cross section, to which fuel is supplied at the top, and is maintained in a state of incandescence by a blast of air or air and steam. The shell may be carried by columns and has beneath it a rotating ashpan supported on rollers or balls. According to the invention, a tube 12 passes centrally through, is secured to and rotates with the ashpan 16. The tube 12 has mounted upon its upper end arms 13 at such a height that the



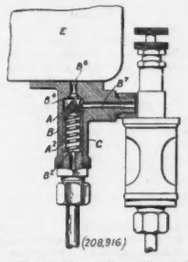
upper surfaces of the arms extend to the top of the ash bed, that is, to slightly below the hollow shell. The arms 13 are preferably triangular pyramids or plough-shaped and are hollow and are provided with outlets. To the end, of the arms is secured a hollow ring 14, which preferably extends beneath and is protected from excessive wear and heating by the wall of the casing 10. The ring is provided with perforations in its bottom or rear wall or in both. An air supply is connected to the tube 12, the air passing through the tube to the arms 13 and the ring 14 and issuing from the perforations in them escapes to the fuel in the casing at points in the upper level of the ash bed, whereby the air has not to pass through the bulk of the ash bed as is usual and is, moreover, supplied to that part of the fuel which has just been agitated by the arms. The arms may be provided with upwardly extending lugs 13 for agitating the fuel preferably so situated relatively to the perforations in the rear surfaces of the arms as to be in advance of them when the arms are rotated. The arms agitate the fuel at the top of the ash bed and their formation causes the ash to be pressed down in the ash pan from which it is removed by a scraper of ordinary construction. (*Accepted January* 16, 1924.)

209,207. M. S. Mason, Buxton, and The Smithbrook Engineering Company, Limited, Chapel-en-le-Frith. Sparking Plugs. (6 *Figs.*) October 12, 1922.—The invention consists in a sparking plug having the central electrode formed with a removable head, this electrode being of mushroom form, the opposite electrode consisting of sectors projecting from the outer casing so that the spark passes between the mushroom-head and these sectors, spaces being provided between the sectors by which the gases can pass to the back of the mushroom head into the body of the plug. The central electrode *a* consists of a rod surrounded by insulation *e* with discs of insulating material *h*,



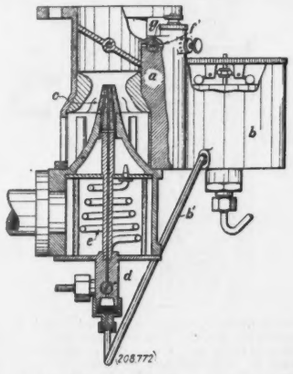
h^1 at the ends of the plug. A flange *n* is formed near the firing end of the electrode *a* and the end of the electrode may be either of the form shown at *c*, Fig. 1, or of the type shown at *c*1, Fig. 3. The end *c* or *c*1 is screwed on to the end of the rod *a* and makes an accurate face joint with the flange *n*. The electrode *a* is secured in the body *b* by means of the nut or gland *d*, which holds the electrode *a* in place against the washer *l*. The body *b*, adjacent to the electrode head *c*, is formed with two projecting sectors *o*, *p* on a flange with apertures between the sectors, through which the gases can pass up into the space between the plug body *b* and the electrode *a*. (*Accepted January* 16, 1924.)

208,916. Dennis Brothers, Limited, Guildford, J. C. Dennis, Guildford, and C. R. Charles, Guildford. Internal Combustion Engines. (2 *Figs.*) January 3, 1923.—The invention relates to lubrication systems for internal combustion engines of the kind in which the lubricant supply is controlled by the suction of the engine acting upon a diaphragm or piston operatively connected to the lubricant control valve. The control valve A for the lubricant is combined with a piston A^2 which works in a cylinder B communicating at B^2 with the induction system of the internal combustion engine. The piston A^2 is coned



or otherwise shaped to constitute the valve A for which a seating B^4 is provided at the adjacent end of the cylinder, and a spring C acts between the cylinder and the piston, normally to thrust the valve against its seating. The end of the cylinder B at which the valve A seats, is attached to the underside of the lubricant supply tank E, and a passage B^6 extends from the valve seat to the interior of the tank E for entry of the lubricant into the cylinder when the valve A is off its seat. Adjacent the latter is a lateral outflow passage B^7 from the cylinder to which the oil delivery conduit is attached. (*Accepted January* 9, 1924.)

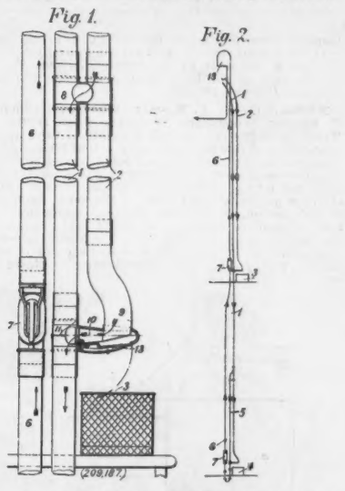
208,772. W. Pickard, Rusholme, Manchester. Carburettors. (3 *Figs.*) September 25, 1922.—The invention relates to carburettors for internal combustion engines of the kind in which two or more fluids entering the carburettor are controlled by valves actuated by or from a pedal. The carburettor casing *a* is provided with a float chamber *b* formed in one



therewith or attached thereto. From the float chamber, the hydro-carbon liquid is led by the pipe *b*1 to the nozzle jet *c*. The supply of fuel from the float chamber is controlled by a cock *d* which is provided with two passages, one to control the flow of hydro-carbon to the jet *c* and the other to control the flow of steam which ascends the coil *e* to the jet *c*. The cock *d* is provided with a lever arm connected to and operated by a rod. The slow-running jet *f*1 is also provided with a cock *g* provided with a lever arm which is in turn connected to the operating rod. The arrangement is such that when the throttle valve is closed, the cock *g* is open, but the cock *d* controlling the steam and hydro-carbon is closed, and *vice-versa* when the throttle valve is open. (*Accepted January* 9, 1924.)

LIFTING AND HAULING APPLIANCES.

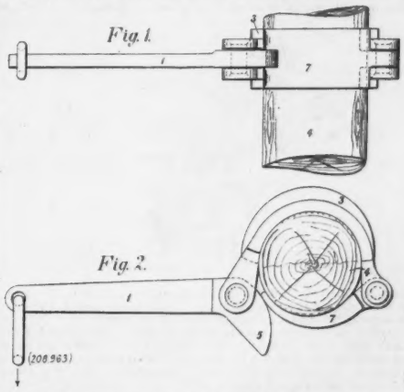
209,187. A. Taylor, York, and E. Backhouse, York. Pneumatic Conveying Systems. (3 *Figs.*) October 5, 1923.—The invention relates to pneumatic despatch systems working upon what is generally known as the continuous flow vacuum system, in which the carrier or load is displaced in a tube by means of a difference in fluid pressure acting on its opposite ends, According to the invention, the speed of a pneumatic carrier is diminished shortly before it is ejected at the terminal by causing it to enter a section of the delivery tube in which the air is flowing at a reduced rate, or through which no air is flowing. 1, 2 is a pair of delivery tubes of which the tube 2 delivers carriers at the station 3, whilst the tube 1 delivers its carriers at the station 4. At the final terminal station 4 the tube 1 is provided with a parallel path 5 connected to the outward tube 6, which is provided with a number of stations 7 for picking up carriers and delivering these at the central station 18 from which the carrier is again sent out by insertion into the ends of either tubes 1 or 2. At a point 8 (Fig. 1) spaced back from the delivery end 9 of the



tube 2, this tube is connected to the next adjacent suction tube 1 and is further connected at its delivery end 9 to the suction tube 1 by a passage 10, the air flow from the delivery end 9 to the tube 1 being controlled by a ported cylindrical valve 11, by means of which flow of air from the point 8 to the delivery end 9 can be completely arrested or else reduced to any desired value as compared with the air flow through the suction tube 1 or to the air flow in the suction tube 2 above the point 8. Assuming that the control valve 11 is entirely closed, but that the point 8 is fully open to the full area of the tube 2, then it is obvious that after a carrier has passed the point 8, it will be subject to a partial vacuum at its back end, being the vacuum in the tube 1, whilst it will be cushioned by substantially atmospheric pressure at its front end, which will serve to absorb its kinetic energy. If a valve is also placed at the point 8 the air flow in that portion of the tube 2 between the passage 10 and the point 8 can be controlled as desired. The delivery end 9 of the tube has its opening covered by a leather-faced hinged flap 13 of usual construction. (*Accepted January* 16, 1924.)

MINING, METALLURGY AND METAL WORKING.

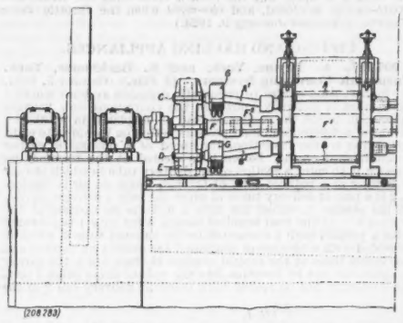
208,963. A. Marshall, Bursiem, Stoke-on-Trent. Withdrawing Pit-props. (4 *Figs.*) March 20, 1923.—A safety appliance for use in withdrawing pit-props comprises a lever 1 fulcrummed to a collar 3 adapted to encircle, more or less, the prop 4 to be withdrawn. A curved member 7 is hinged to the



collar 3 at a point opposite the fulcrum of the lever 1 and bears against the prop 4. A cam or curved surface 5 on the shorter arm of the lever 1 is adapted, when tension is applied to the end of the long arm of the lever by means of a "Sylvester" or other safety contrivance, to grip the prop. The prop is thus gripped and can be turned on its axis until it is free. (*Accepted January* 1, 1924.)

208,283. Duncan Stewart and Co., Limited, Glasgow, and T. E. Holmes, Glasgow. Plate-Rolling Mill. (1 *Fig.*) October 7, 1922.—According to the invention, all three rolls are positively driven through universal shafts and slip is obviated

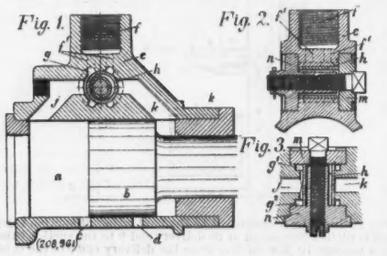
by the provision in the driving means for the top and bottom rolls, of relief devices adapted to slip upon a predetermined torque passing through them being exceeded. The top and bottom rolls A, B are driven through universal shafts A^1 B^1 and



(208,783)

couplings from gear driven lay shafts C, D in a gear housing E from the central shaft F of which the central roll F^1 is driven through a like shaft F^2 and couplings. The relief devices G are arranged on the lay shafts C, D near the gear housing E. (*Accepted December* 28, 1923.)

208,961. G. H. T. Rayner, Woodseats, Sheffield, and P. Rayner, Woodseats, Sheffield. Rock Drills. (5 *Figs.*) March 14, 1923.—The invention relates to valve apparatus for rock drills and like fluid pressure operated tools. *a* is the main cylinder, *b* the piston therein, *c*, *d* being exhaust ports opened and closed by movement of the piston. *e* is a valve casing with a main fluid inlet *f* communicating by four ports *f*1 with the valve chamber *g*. In two end walls of the valve chamber are arc-shaped ports g^1, g^2, which are always in communication with the inlet through the ports *f*1 and permit fluid pressure to pass to the under-part of the valve *h*. *h* is a hollow cylindrical valve controlling the admission of fluid to each end of the cylinder through ports *j* and *k*. The valve chamber *g* is closed at the sides

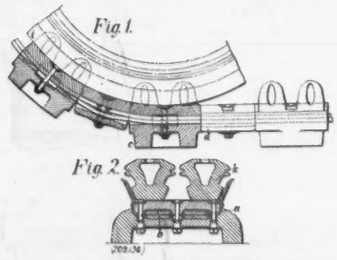


(208,961)

by circular end plates *m*, *n*. In operation, with the valve and piston in the position shown, fluid having entered at *f* and passed into the valve chamber *g* through the ports *f*1 and then over the left-hand side of the valve into the inlet *j* to the cylinder at the left-hand end of the piston, has forced the piston over to the right on its forward stroke, thus closing exhaust port *d* and compressing fluid to the right of the piston and opening exhaust port *c*. The incoming fluid to the left of the piston now being open to exhaust, the compressed fluid to the right of the piston and in the inlet port is sufficient to throw the valve over to the left, thereby closing the inlet port *j* and opening the inlet port *k*, whereupon fluid entering the cylinder to the right of the piston, forces the piston to the left on its return stroke when the above operation is repeated. (*Accepted January* 9, 1924.)

MOTOR ROAD VEHICLES.

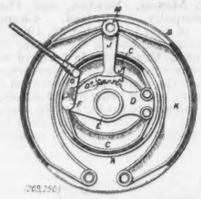
209,130. J. T. Dreyer, London. Endless Track Vehicles. (4 *Figs.*) August, 8, 1922.—The invention relates to endless tracks for self-propelled vehicles of the type comprising one or more endless bands having a plurality of shoes mounted thereon and adapted to be driven by means of one or more wheels. The invention consists in an endless track for vehicles comprising one or more endless bands having a plurality of shoes mounted thereon and one or more driving wheels each having a friction



(209,130)

surface adapted to drive by frictional contact with the shoes, *a*, *b* are duplex belts on which the shoes *c* are mounted, the shoes being separated by distance-pieces *d*, which provide gaps between adjacent shoes to prevent the track slipping on soft ground. The endless track is driven by the wheel member *i*, which has single or twin solid tyres *k*, and the drive is effected by frictional contact between the surface of such wheel member and the shoes. (*Accepted January* 16, 1924.)

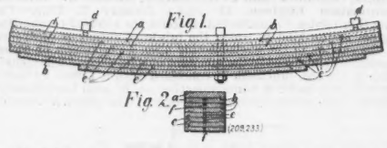
209,250. Sunbeam Motor Car Company, Limited, Wolverhampton, L. Coatalen, Wolverhampton, and H. C. M. Stevens, Wolverhampton. Brakes. (1 *Fig.*) November 17, 1922.—The invention relates to brakes for use on vehicles of the kind in which there are two sets, of which the one brake is applied by the driver, and the movement of part of this with the wheel applies the second brake. The second brake is herein called the main brake, and the brake which is applied by the driver is called the servo brake. According to the invention, two concentrically arranged brake drums are employed, each brake drum having its own brake shoes carried by separate anchor plates The anchor plate of one brake can move around the axis of the drums, and it has a connection with the applying mechanism of the other brake. The two brake drums A, B are concentrically arranged and attached to a road wheel. Arranged within the brake drum A are the two shoes C pivoted to an anchor plate D. This anchor plate is formed with a hub E adapted to twist upon the axle, and the anchor plate carries the usual expander F to which is connected a lever G coupled by a rod to a brake lever. A^5 D^4 on the anchor plate are formed teeth in the form of a quadrant engaging similar teeth J2 upon a lever J attached to the expander



(209,250)

engaging the shoes K which lie within the main brake drum B. When the rod is pulled it expands the shoes C, creating friction against the drum A which is revolving with the wheel. This frictional engagement causes the anchor plate D to move slightly around the axle in the direction of rotation of the wheel. The teeth D^4 consequently move the lever J which expands the shoes K, applying them forcibly to the interior of the drum B so that the main brake is thus applied. The spindle M, which carries the lever J and the shoes K, is not attached to the same anchor plate D which carries the shoes C, but is carried by a fixed anchor plate. (*Accepted January* 16, 1924.)

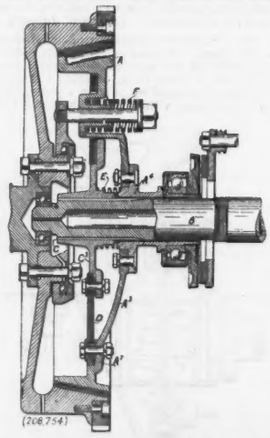
209,233. Sir R. A. Hadfield, Westminster, and A. B. H. Clerke, Sheffield. Springs. (2 *Figs.*) October 28, 1922.—The invention has for its object to provide springs that can be easily and economically made and efficiently and economically lubricated. For this purpose, a spring according to the invention is formed of a special section of steel, each leaf *a*, except the top or master leaf, being formed on its flat upper surface and towards its outer edges with slight upwardly extending longitudinal ribs *b* fitting into corresponding grooves *c* in the lower flat surface of the leaf above, so that the space between the ribs forms a shallow longitudinal trough or space along which oil can spread readily under the movement of the spring, the inter-engaging ribs and grooves serving to maintain the oil in place and prevent it escaping at all sides of the spring from between the leaves. In order to



(208,233)

simplify lubrication, communication must be made between the several pairs of working surfaces so that the oil can be supplied to such surfaces from a single lubricator *d* or from a lubricator *d* on each arm of the spring. For this purpose, a hole *e* is formed through each leaf, except the bottom one, in such position that the several holes are staggered towards the centre of the spring from the top leaf thereof to the bottom one, and the distribution of the oil is, or may be, further assisted by a longitudinal groove *f* formed in the upper surface of each leaf, except the master leaf, without any corresponding rib being formed on the lower side of the leaf above. Incidentally, the inter-engaging grooves and ribs near to the outer side portions of the spring will assist also to keep the various leaves in register. (*Accepted January* 16, 1924.)

208,754. Sunbeam Motor-Car Company, Limited, Wolverhampton, L. Coatalen, Wolverhampton, and H. C. MacStevens, Wolverhampton. Friction Transmission Clutches. (1 *Fig.*) September 1, 1922.—The invention relates to cone friction transmission clutches of the kind in which the supporting means and the transmission means for the axially movable friction element are separate from one another, the former providing for its axial and independent rotational freedom, while the drive is transmitted to the clutch shaft through a flexible disc which allows the necessary axial movement for engagement and disengagement of the clutch element. The

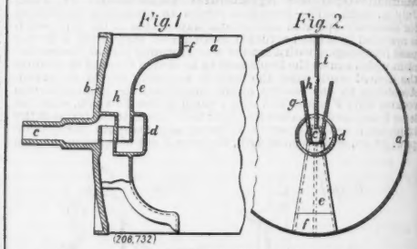


(208,754)

sliding clutch member comprises a coned rim A on which the clutch surfaces are provided, and this rim is supported by a disc A^3 which is attached to a hub A^4, rotatably and endwise free upon the clutch shaft B. A second hub portion C is provided which is arranged upon the clutch shaft B, adjacent to the hub A^4, and is provided with splines for establishing a driving connection with splines on the shaft B, which will allow also for its axial movement. Around this hub is a radial flange C^3, and between this flange and the rim A is located an annular disc D of resilient material, the inner and outer peripheries of which are bolted respectively to the flange C^3 and to a suitably-prepared portion of the disc A^3. A compression spring E may be provided between the two hub parts A^4 and C, so that the normal tendency is for them to be thrust apart from one another. Any convenient arrangement of clutch engaging spring may be employed, and preferably a number of compression springs F is spaced around the clutch disc A^3. (*Accepted January* 9, 1924.)

TEXTILE MACHINERY.

208,732. G. P. Roberts, Bury, and R. R. Roberts, Limited, Bury. Drying Fabrics. (4 *Figs.*) June 20, 1922.—The invention relates to drying cylinders, such as are employed in connection with fabrics, of the type which are heated internally by steam. *a* indicates the shell of the cylinder, *b* the end to which it is secured and *c* the hollow trunnion. The invention consists in forming a central chamber *d*, preferably of cylindrical formation and in axial line with the trunnion *c*, such chamber being formed in one with radially projecting members *e*, the end parts *f* of which pass out to the interior surface of the cylinder, whilst the side members *g* are stopped short at a point nearly mid-way between the axis of the cylinder and its periphery so as to provide passages *h* leading to the chamber *d*, the discharge ends of such passages terminating at a point below the axial line of the cylinder as each of them reaches the position shown at the right-hand end of Fig. 1, whilst each of them in consequence stands at a higher point than the axis of the cylinder as it reaches the position, shown at the left-hand end of Fig. 1. The passages *h*

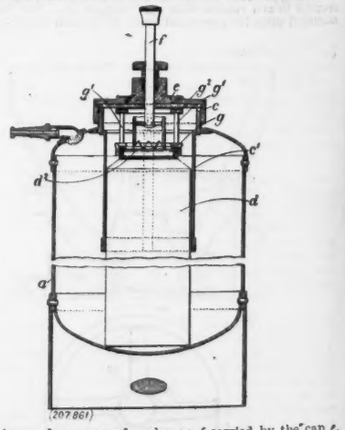


(208,732)

are formed by the central web *i*, the inner end of which terminates a little distance away from the axis of the cylinder. The chamber *d* communicates with the trunnion *c*. All the parts of the bucket referred to are formed integral with the end of the cylinder. With the bucket arrangement constructed as described, the water of condensation is picked up by each end of the bucket as the cylinder revolves and is directed down one side of the central web *i* into one of the passages *h*, and is thence discharged into the chamber *d*. In Fig. 1 the right-hand passage *h* is in the discharging position, the water passing from the chamber *d* and out through the hollow trunnion. The left-hand end of the other discharge passage *h* is at this time substantially in line with the upper part of the bore of the trunnion so that no water can pass back from the latter through the passage to the cylinder. The same conditions occur when the positions of both passages are reversed. It should here be said that the bucket construction, described and shown, is arranged to act in the same way when the drying cylinder is rotated in either direction. (*Accepted January* 9, 1924.)

MISCELLANEOUS.

207,861. Minimax, Limited, Feltham, Middlesex, and G. A. Gregory, Seven Kings, Essex. Fire Extinguishing Apparatus. (1 *Fig.*) September 5, 1922.—The invention relates to hand fire-extinguishing apparatus of the kind in which two chemicals contained therein are maintained separate until the moment of use. According to the invention, the fire extinguishing apparatus comprises an outer container *a* provided at the upper end with an opening *c* of considerable area adapted to be closed by a cap *e* and an inner receptacle or container *d* for introduction through the mouth *c* of the outer container *a* and fitted in such manner as to be maintained in position within the outer container, notwithstanding the movements to which the latter may be subjected. The inner receptacle *d* is provided with an opening at the upper end adapted to be closed by a disc d^2 of glass or other frangible material secured in position by a closing ring *g* fitting upon the mouth of the receptacle, the disc d^2 being adapted to be broken when the apparatus is to be



(207,861)

brought into use by means of a plunger *f* carried by the cap *e*. The retaining ring *g* of the inner receptacle *d* is provided with a cage or frame g^1 adapted to extend into the mouth *c* of the outer container *a* and provided at the outer end with a ring g^2 adapted to contact with the inner face of the cap *e* of the outer container when the latter is secured in position. By such means the inner receptacle *d* is maintained against movement upon the inversion of the outer receptacle *a*. The cage or frame g^1 carried upon the inner receptacle *d* may be of dimensions to fit closely within the mouth *c* of the outer container *a*. It may, however, serve merely to prevent the longitudinal movement of the inner receptacle *d* while lateral movement may be prevented by a cage or frame e^1 secured within the mouth *c* of the outer container and adapted to surround the inner receptacle. The bottom of the outer container may be provided with a recess or seating or with an upstanding annular projection for the reception of the lower end of the inner receptacle. (*Accepted December* 19, 1923.)